HINES AUTOMOBILE BOOK

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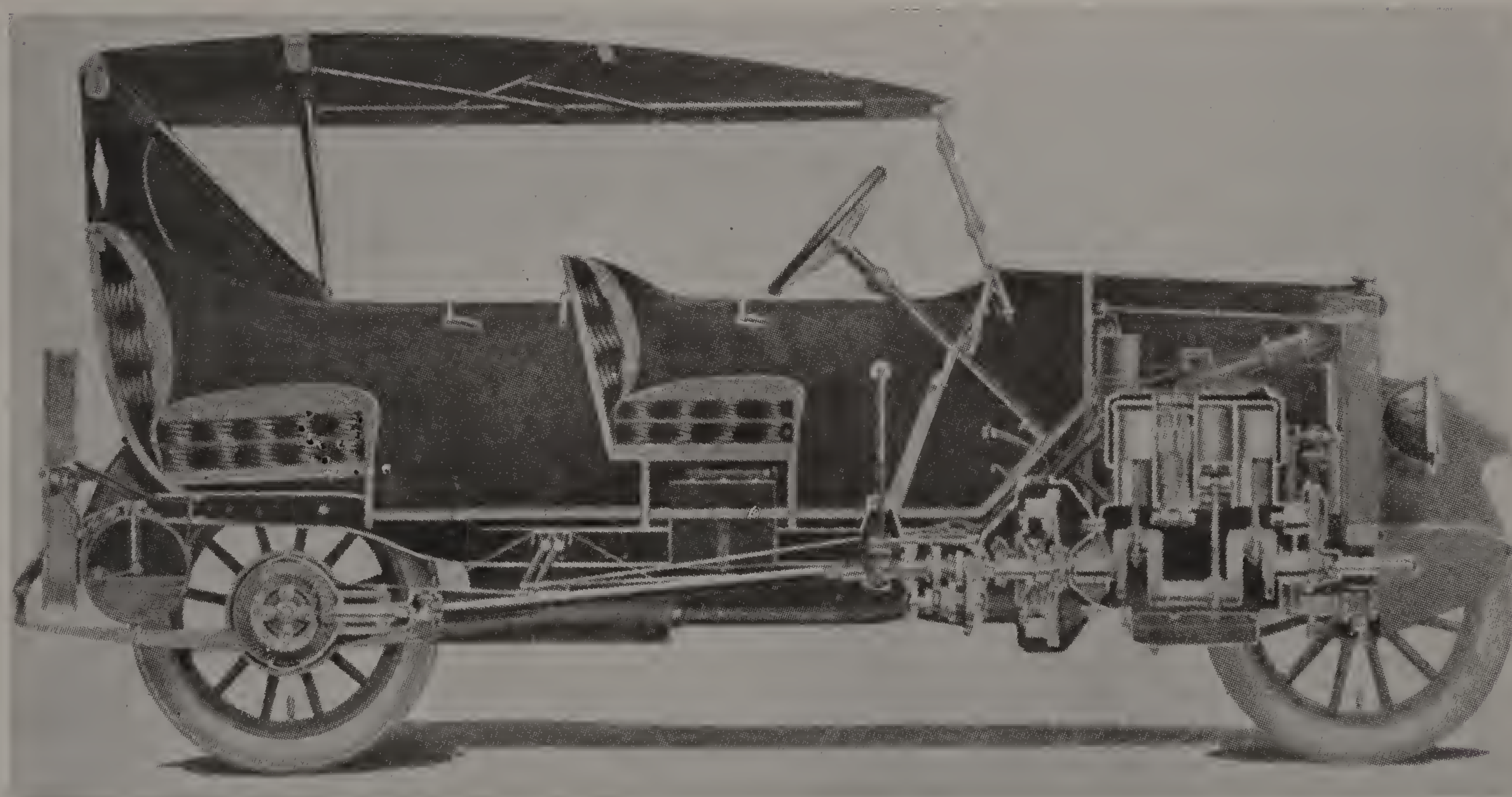
ILLUSTRATED

The Progressive Farmer Company
PUBLISHERS
Raleigh, N. C., Birmingham, Ala., Memphis, Tenn., Dallas, Tex.



—Courtesy Allen Motor Car Co.

Fig. 1.—SECTIONAL VIEW OF A MODERN AUTOMOBILE

This Book is Dedicated

To

THE MAN OF AVERAGE MEANS

Who is Able to Own and Operate an Automobile
Only by Strict Economy, in the Hope That
It Will Enable Him to Get Better Ser-
vice and More Pleasure From His
Car With the Least Possible
Outlay of Money

PREFACE.

THE automobile has done much to smooth the rough road of life, especially country life. It has enabled the farmer to keep in closer touch with his neighbors both socially and agriculturally; and has also brought to the farmyard gate everything of worth in the city, while none of the country's freedom, peace, quiet, or wholesomeness has been sacrificed. It has made possible the speedy dispatch of pressing business, and has simplified many perplexing problems of farm marketing.

And modern methods of manufacturing automobiles in quantity have so reduced the price of cars that many people now own machines who a few years ago dared not even dream of such a possibility. They now find the ownership of a car not only possible but profitable.

In a large number of cases, however, the knowledge of automobile mechanics has not kept pace with the sale of cars—and even the literature furnished with machines by manufacturers is often thrown away without being mastered. It is with the belief that there is need for a simple, easily-understood automobile book therefore that this volume has been written; and it is sent out with the hope that it will meet the needs of the automobile owner of average means.

P. T. HINES.

CONTENTS.

CHAPTER I.

Advice to the Purchaser of a New Car

WHEN a man buys a new automobile the salesman usually teaches him the things it is necessary to know in order to get the car going, and then gives him certain books of instruction to take care of the other essential points of operation and care.

The average man remembers enough of the salesman's instructions to get the car home. In fact, he usually gets along so well in making this trip that he forgets about the instruction book altogether. Everything goes nicely for awhile and then he wonders why his car suddenly gives so much trouble.

Do not make this mistake. There is no book printed, no matter how complete, that will take the place of the instruction book of your particular car; and if you wish to get the best possible service from your automobile, you will diligently study what the makers say about caring for it. Books are to supplement and clarify things treated in instruction booklets—not to take the place of them. And if any automobile owner who has not mastered the instruction booklet of his particular car starts to read this book, I hope he will stop here, get a copy of such instructions, and master them. If the booklet that came with your car has been lost, worn out by being kept in the tool box, or if certain pages of it have been torn out, a new copy may be obtained either by writing the dealer or the manufacturer.

In his instruction book the car owner will find information about lubrication, specifying certain kinds of oils for

various parts; instructions for carbureter adjustments; the care of the cooling system; and the adjustment of bearings. And no matter how much you know about these subjects, you do not know as much as the experts who are employed by the manufacturer of your car and who have given you rules to go by in the form of an instruction book.

Probably 90 per cent of the complaints that come to automobile salesmen are due to ignorance on the part of the car owner; and this ignorance is in turn due to a lack of study of automobile construction, principles of operation and the problem of intelligent care.

Nor should the driver feel that the speed at which he runs his car should be increased with his experience. Fast driving does not mean good driving but usually indicates just the opposite. People should be especially careful when driving on crowded city streets or on roads where there is a great deal of traffic. Under such conditions, the speed of a car should never be so great that it could not be stopped within a very few feet.

Of course, on good country roads where there are no crossings, little travel, and one can see ahead, a car may be driven at a greater speed than on city streets. But even under such conditions, fast driving is imprudent as well as uneconomical. One will get most miles for the least money spent by keeping the speed limit around 15 to 20 miles an hour.

When driving in town, one should always keep to the right—and this applies when turning corners. There is a tendency on the part of most drivers to "cut corners" and turn on the left-hand side of the center of street intersections.

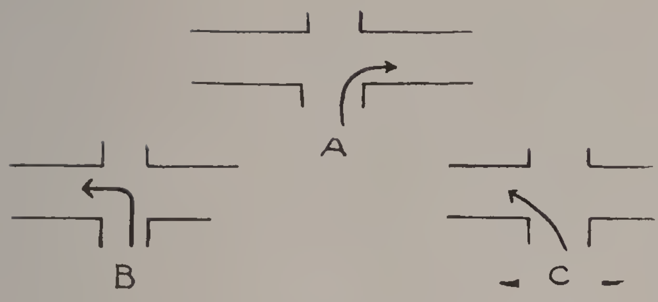


Fig. 2.
(a) Shows Proper Way to Turn to right; (b) Right Way to Turn to Left; and (c) Wrong Way to Turn to Left.

If there is a building near such a corner and a driver gets on the wrong side in his haste, there is likely to be a head-on collision with an unseen car coming in the opposite direction. (Fig. (2). Remember, however, the one exception to the "Keep to the Right" rule. The exception is when one overtakes and passes another car, when he should drive to the left.

Most states, by law, now compel automobile owners to equip their cars with "anti-glare" headlights to make night driving less dangerous. When two cars are approaching each other at night, the glare of undiffused light is blinding to each driver and there is danger of having a serious accident. Even the new lenses automobile owners are forced to place in their headlights do not entirely eliminate the danger and it is a fine act of courtesy on the part of drivers to dim their lights when approaching each other; and it is also a "safety-first" measure.

CHAPTER II

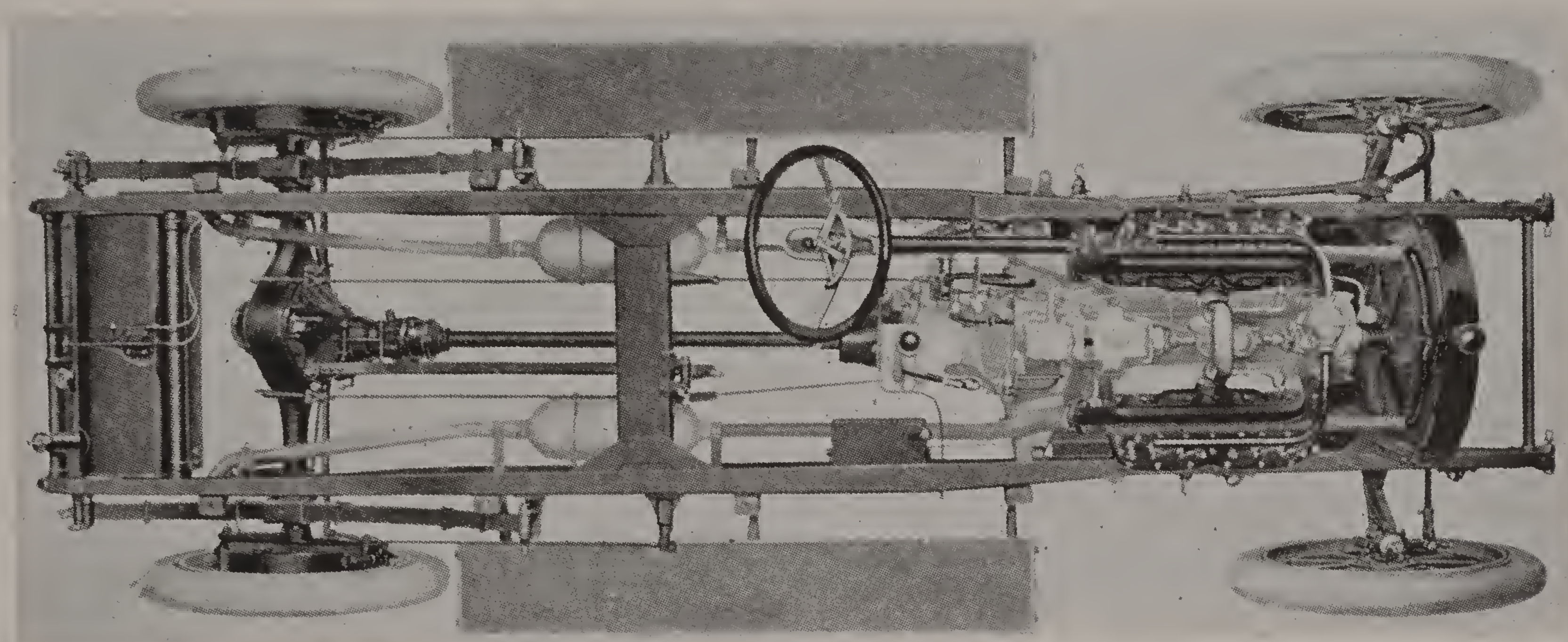
Gaining Confidence In Yourself and Your Car

THE basis of confidence is knowledge. The person who can go before a big audience and play a piano, sing a song, or make a speech, or act a part in a play without a tremor, is a person who knows what he or she is to do—a master! The person who takes the driver's seat in an automobile with perfect confidence therefore is one who knows something about a car—knows its make-up and how it should be operated and cared for.

The first thing to study is the car itself. Learn what every part is for and then how to care for that part. Learn the care of the gasoline system, the transmission system, the power system, the lubricating system, the cooling system, the tires, the wheel bearings, and all the other parts and individual units of these various systems.

Being prepared for an emergency also gives one confidence. If you have extra tires and inner tubes along, you do not worry about having a puncture or a blow-out. In the same way you do not fear ignition trouble if you have spare spark plugs; or about the motor getting out of oil if you inspected it before you started on your trip and also have a spare can of oil in the tool box.

You can have much more confidence in a car cared for by yourself altogether than you can in one that is operated by Tom, Dick and Harry. When you depend on yourself alone, you know what kind of inner tubes are inside the casings and whether or not they are well dusted with powdered soapstone. You know whether or not the right kind of oil is being used in the transmission case. You know whether or not the lubricating system has been cleaned out recently. You



—Courtesy Cadillac Motor Car Co.

Fig. 3.—CHASSIS OF A MODERN AUTOMOBILE

know whether or not the gasoline tank has been kept free from sediment. You know whether or not the carburetor is adjusted for most economical operation, and so on. Until a driver knows these things, he cannot have absolute confidence in the car he is driving nor in his ability to take the car out on the road and get back home with it again. Every noise startles him and he wonders if everything is in good shape.

Confidence in driving a car—the belief that one can control it under all circumstances—comes from constant and painstaking practice and in the very beginning a driver should determine to become not merely an ordinary automobile driver, but a super-driver. Even if you think you are a good driver, it will pay to go back to the most simple fundamentals and make sure of every step.

A good place to learn to drive a car is in an open, firm, level field of two or three acres extent. With such a field, one may start a car without being afraid of running into something in a moment of excitement.

The first lesson to learn is to keep cool. Don't get excited, for if you do, you are almost sure to get into trouble. Mastery of a car comes by going slowly and learning lessons well. Being sure of yourself will prevent excitement.

We will presume that you have your car in an open field ready to begin learning. Now then, after being sure that oil, water, and gasoline are in the right places, get your instruction book and turn to the place telling how to start your particular make of car.

First learn how to start the motor. The spark lever should be in retard when starting the engine, and advanced while running. It is usually necessary to set the throttle well open when starting. When the throttle and spark levers have been set,

the switch should be thrown in and the motor is then ready to be cranked either by hand or self-starter.

When the motor starts, do not allow it to race, but close the throttle until it is running at a moderate speed. Start the motor several times and try to develop a method of starting that will be quiet. If the engine starts with too much vim the first time, start it with less throttle-opening the next time.

Gear shifting is quite an art in itself and it will require much practice to master it. The ideal way to shift gears is to make the changes when the meshing gears are running in proper ratio to each other. If this is done, engagement will be made without noise.

In changing from a lower to a higher gear therefore, it will be well to speed up the engine a little just before disengaging the clutch for the change and let the car gain considerable momentum. Then push in the clutch, hesitate a moment, and make the change to the higher gear while the car is moving rapidly ahead and the clutch turning slowly. With a little practice in this particular, you will soon be able to shift gears without any grinding noise whatever.

When starting from a standstill, however, the engine should be running slowly. Let in the clutch gradually and if the engine slows, slightly increase the amount of gasoline fed. Don't let the motor be running like a race-horse and then drop the clutch back suddenly. .Practice starting slowly and gently for awhile and you will not be annoyed by having your car try to jump from under you when starting to leave town or the church.

Also use as much care in stopping as you do in starting. Never jam the brakes (except in case of an emergency) but apply them gradually. Begin to stop some distance from the

"stopping place" and you won't have to use the brakes very much.

Learn carefully the lesson of controlling your car, and you will find that your confidence will grow with your knowledge of automobile mechanics.

CHAPTER III

Why a Motor Runs

THE principle on which gasoline engine operation is based is the same as that of a gun. That is, power is obtained by rapid combustion, or explosions, acting in one case on a bullet or a charge of shot and in the other case on a movable piston.

The first operation in firing a gun or securing an explosion in an engine cylinder is to fill the combustion space with combustible material; the second operation is to compress this material; while the third operation is to ignite it.

In the case of the gun, the charge will be driven from the barrel, while in an engine the piston will be driven toward the open end of the cylinder. The gun is automatically cleared of burnt gases as the charge leaves the barrel, while the engine cylinder is cleared by the opening of the exhaust valve through which the burnt gases are forced out by the return stroke of the piston.

From the foregoing it will be seen that the piston has four distinct movements: (1) down stroke or intake; (2) up-stroke or compression; (3) down-stroke or power-stroke; and (4) up-stroke or exhaust.This gives one power stroke from each cylinder for every two revolutions—a four cylinder engine delivering a power stroke every half revolution of the crankshaft.

An engine of this type is called "four-cycle" and the operation will be readily understood by referring to the illustration (Fig. 4). The term "four-cycle" is really misleading, as a cycle signifies an orb or circle. The term "cycle," however, as applied to gasoline engines, refers to the movement of the piston, there being, as we have already learned, four move-

ments of the piston to every complete function of the engine—two upward and two downward.

Pistons are connected to the engine crankshaft in pairs. That is, in a four-cylinder engine two pistons are always moving opposite the other two. When Nos. 1 and 4 are going down, Nos. 2 and 3 are coming up, and vice versa.

A flywheel is used to store up energy during explosions and deliver it back to the crankshaft between explosions. This gives a fairly smooth and even delivery of power at all times.

As the piston C (Fig. 4) moves downward on its first stroke, the cam A raises the valve in the intake manifold B (which is connected direct to the carburetor, though not shown in the drawing) and the moving piston draws a current of air through the carburetor, past the spray nozzle where it takes up a charge of gasoline and on into the cylinder of the motor.

Then the piston moves upward with both intake valve B and exhaust valve E closed. This is the compression stroke which drives the mixture of air and gasoline into a small space in the upper part of the cylinder.

As the piston nears the top of its compression stroke, the ignition system of the motor sends an electric spark

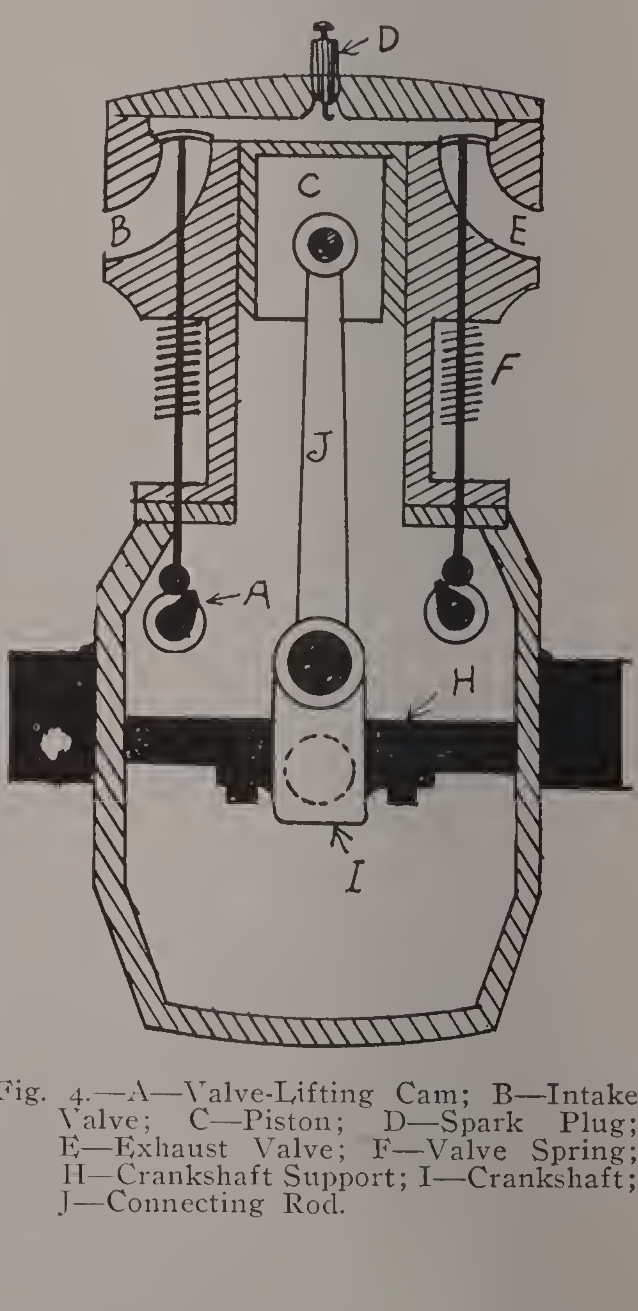


Fig. 4.—A—Valve-Lifting Cam; B—Intake Valve; C—Piston; D—Spark Plug; E—Exhaust Valve; F—Valve Spring; H—Crankshaft Support; I—Crankshaft; J—Connecting Rod.

through the sqark plug D and ignites the gas. The gas then expands because of combustion and drives the piston again downward on what is called the power stroke.

After this comes the upward stroke, with exhaust valve E open, driving out the burned gas and preparing the cylinder to again repeat these operations.

In trying to locate automobile troubles, these four points should always be kept in mind:

1. The motor must get a proper mixture of air and gasoline.

2. This mixture must be well compressed.

3. It must be ignited at the proper time.

4. The burnt gas must be expelled at the right instant.

If these four conditions are met, an engine will run; if one essential is lacking it will refuse to operate.

CHAPTER IV

Carburetors and Their Troubles

WHAT is a carburetor? It is a device for mixing liquid fuel and air in such proportions that the mixture will be readily ignited—"catch fire"—from an electric spark. You may pour gasoline or kerosene on a board and ignite it with a match but it will burn very slowly for the reason that it mixes with the air very slowly.

In fact, all combustion is rapid or slow in direct ratio to the rapidity with which the carbon of any fuel mixes with air. In the stove, for example, the fire may be controlled by regulating the draft; the finer the wood is split the more rapidly it burns; and it is reasonable to believe that if light dry wood — which means wood of high carbon content—were shredded fine enough and held loosely apart so that the proper amount of air would be among the particles, it would burn almost rapidly enough to approach an explosion.

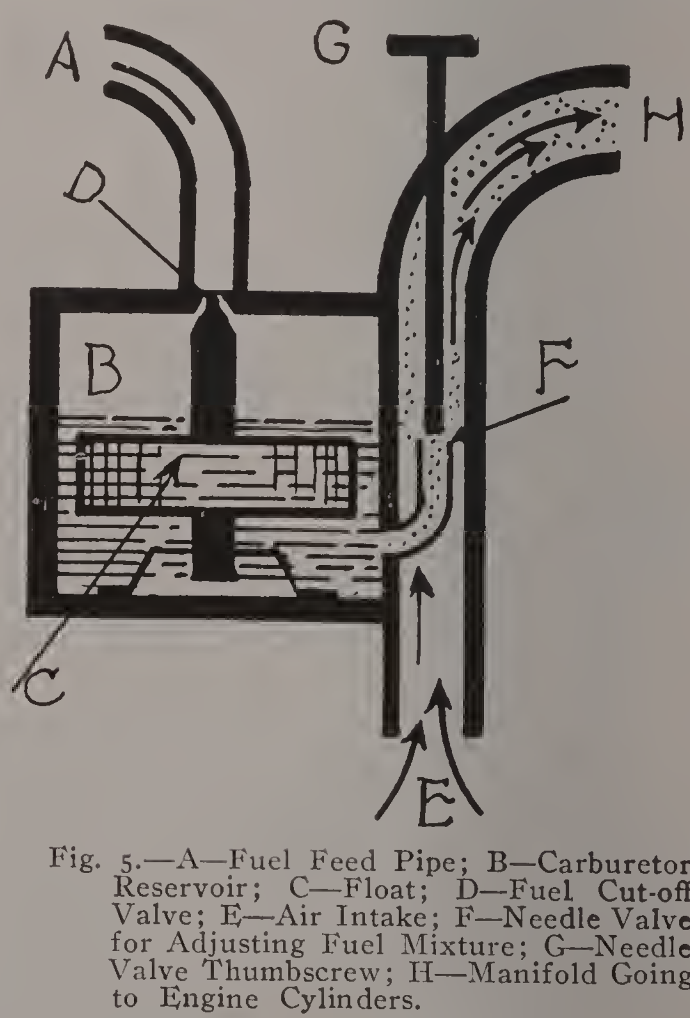


Fig. 5.—A—Fuel Feed Pipe; B—Carburetor Reservoir; C—Float; D—Fuel Cut-off Valve; E—Air Intake; F—Needle Valve for Adjusting Fuel Mixture; G—Needle Valve Thumbscrew; H—Manifold Going to Engine Cylinders.

Gunpowder is an example of the proper mixtures of the elements necessary to rapid combustion, for when a spark is introduced, the combustion is in-

stantaneous. The secret of the rapidity is that the elements necessary to combustion are well mixed when they ignite or "catch fire" and therefore burn at once instead of by piecemeal.

A carburetor therefore is a device for mixing two elements, neither of which will burn alone, in such proportions that they will burn very rapidly or explode when ignited.

The illustration herewith shows the almost universally used feed-type carburetor. Through the gasoline feed pipe A the gasoline from the fuel tank runs by gravity into the bowl of the carburetor until the float C raises the needle valve and cuts off the flow of fuel at D. As the pistons of a motor travel downward, they create a vacuum in the cylinders, causing air to rush to them through the air inlet E. As the air passes the needle valve F it becomes saturated with gasoline vapor—the raw gasoline being drawn out in a mist or fog by the suction—and gasoline and air are converted into what is called "gas."

The efficiency of the carburetor depends wholly on the kind of gas mixture it delivers to the cylinders. There is some question as to what constitutes the best mixture, and every car operator must determine just what mixture best suits his car. A gas mixture is considered explosive when 1 part fuel is mixed with from 4 to 18 parts of air. The fact is, however, that a 1-to-4 mixture is much too rich, while a 1-to-18 mixture is much too lean for positive ignition.

A rich mixture should be avoided because the excess fuel used will deposit carbon on the piston and cylinder walls as well as the valves and thus tend to overheat the motor. A rich mixture will also not give a flexible and responsive engine. A rich mixture may be readily discovered by black

smoke coming from the muffler, while if the mixture contains too much air, there will be popping sounds in the carburetor or muffler, which is commonly termed "back-firing."

Adjusting the carburetor is not a difficult matter when the purposes of the various control members are understood. The first thing to do is to start the motor and open the throttle enough for the engine to run at a fairly good speed. When it becomes necessary to adjust the carburetor cut down the gasoline flow by gradually screwing down the needle valve until the motor begins to run irregularly or misfire. When the motor begins to misfire, unscrew the needle valve till the motor reaches its highest speed. When this adjustment is secured, lock the needle valve in place, with the lock-nut which is usually provided.

Perhaps the most frequent carburetor trouble is the accumulation of dirt or other foreign matter at the inlet needle valve D shown in Figure 5. This foreign matter will often collect and prevent the needle from seating properly. The flow of gasoline will therefore not be stopped and the level in the carburetor bowl will consequently get so high that it will flow out past the needle valve F even without any suction from the engine. This will cause flooding and the engine will "choke down" if the flow is very free. When the engine is stopped the flow will continue and there will be a big loss in gasoline from this leakage if the trouble is not remedied. Sometimes the foreign matter can be dislodged by tapping the carburetor and jarring it slightly or by speeding up the engine. If this does not remedy the trouble, disconnect the inlet pipe and thoroughly clean the needle and its seat. Sometimes the trouble is caused by a worn needle valve, and when this is the case a new one should be pur-

chased or the old one ground to a seat by the use of fine grindstone or emery dust.

Lack of gasoline may be caused by a clogged fuel pipe leading from the gasoline supply tank to the carburetor or by foreign matter collecting in the needle valve passage at F. The gasoline pipe must usually be unstopped by disconnecting it at both the carburetor and fuel tank and thoroughly washing it out, while the clogged needle valve may usually be unstopped by slightly opening the needle valve and speeding up the engine until the foreign matter has been sucked out.

The floats used in carburetors are made either of hollow metal or of cork. These may cause flooding when the former becomes punctured or the latter oil-soaked. The remedy is to solder the puncture in the metal float or remove the cork float, dry it in the sun, and give it a light coat of shellac.

Air leaks about the carburetor, intake manifold, cylinder head, spark plugs or priming valves will also cause a poor mixture to be delivered to the cylinders. In fact, if additional air is introduced into the mixture in any way after it leaves the carburetor, it will cause a weak mixture to be delivered to the cylinder. Therefore, keep good gaskets between all connections as well as keep the connections themselves tight.

CHAPTER V

Vacuum Fuel Feeds

ON CARS that have vacuum fuel feed two gasoline tanks are placed. One tank, the storage tank, is placed somewhere on the car chassis and the other tank, the vacuum tank, is placed on the dash of the car under the hood. The vacuum tank is connected to the main supply tank by a copper tube, the connection being shown in Figure 6 at the place marked D. Then another copper tube is run from C in the same diagram to the intake manifold of the engine.

We now will assume that the main gasoline supply tank is full of gasoline but that the vacuum tank is empty. How will the fuel get to the vacuum tank and thus to the carburetor—for the vacuum tank is higher than the supply tank and neither water nor gasoline will voluntarily run up hill?

It works this way. If there is no gasoline in the vacuum tank it is evident that the float G (Fig. 6.) will drop down toward the bottom of the "upper chamber" of the vacuum tank. When this is done the opening marked "air vent" will be automatically closed by the valve B which will be forced in the opening R or the outlet to the air vent. Now, if you crank your engine, the pistons will draw the air out of the upper chamber of the vacuum tank through the tube C. There is always an atmospheric pressure of approximately 15 pounds to the square inch at sea level, and as the main gasoline supply tank is ventilated or has an air opening, the air will virtually "push" the gasoline out of the supply tank up hill to the vacuum tank where the air has been removed and there is no resistance to its flow.

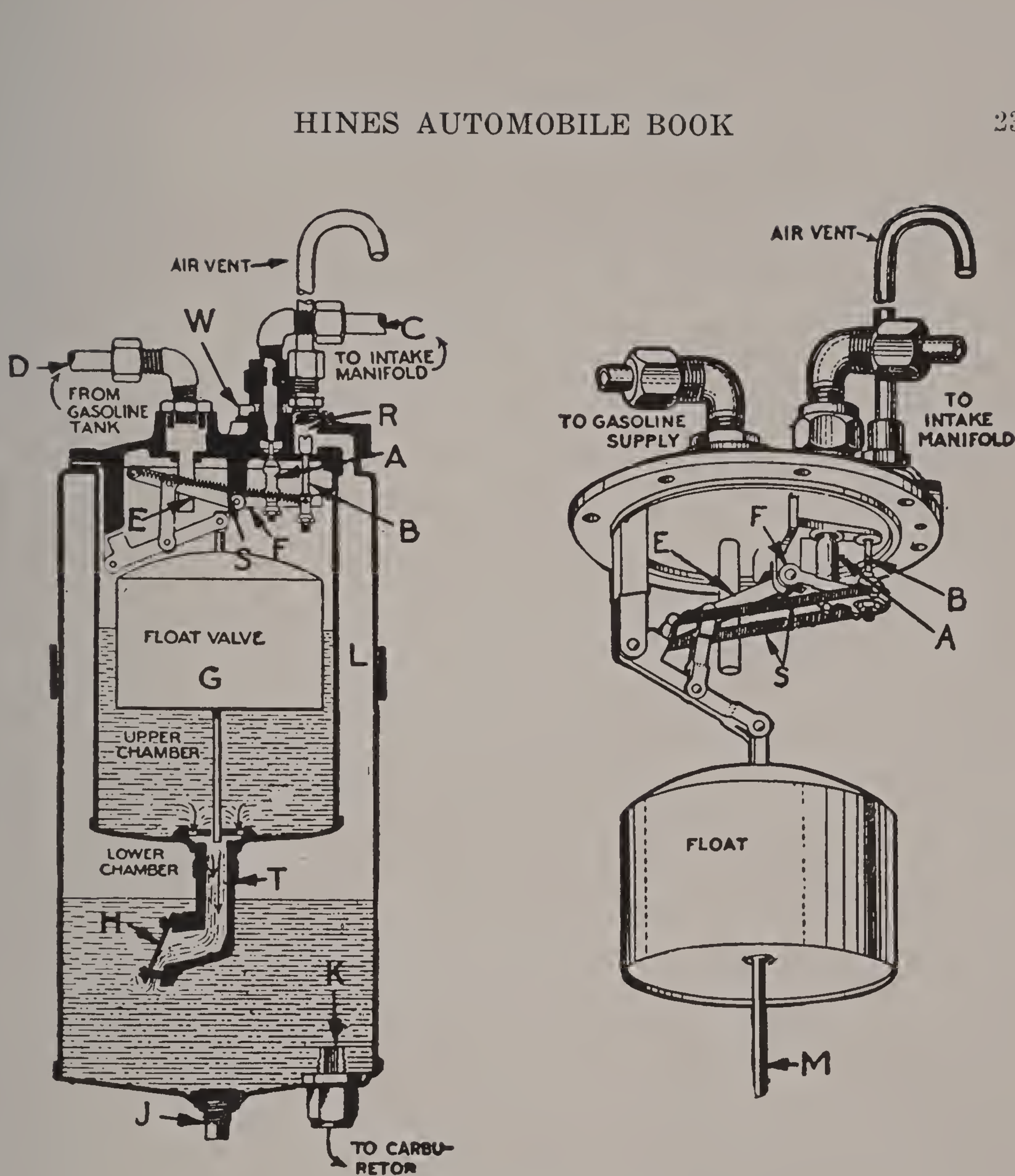


Fig. 6.—VACUUM TANK

A—Suction Valve; B—Atmospheric Valve; C—Pipe to Suction Yorke; D—Pipe to Main Tank; E—Valve Lever (long); F—Valve Lever (short); G—Float; H—Flapper Valve; J—Drain Plug (omitted on some tanks); K—Pipe to Carburetor; L—Air Passage; M—Float Guide; R—Air Vent; S—Valve Springs; T—Flapper Valve Housing; W—Priming Plug.

When the lower chamber has received its normal supply of gasoline and the upper chamber begins to fill, the float is raised by the incoming gasoline until the air vent is opened by the valve B, thus breaking the vacuum and stopping the flow of gasoline. When the gasoline is used out of the upper chamber again, the float valve drops, the air vent is closed,

a vacuum is again formed and the tank is filled once more. And so on.

The vacuum fuel system rarely gives trouble and when in good shape is positive in its action. The main thing is in keeping both the main tank and the vacuum tank clean and free from sediment. For this reason, gasoline should be strained as it is put in the gasoline supply tank; and it will be well to clean the tanks themselves once for every 2,500 miles a car is run.

To clean the vacuum tank, remove the pipe line to the carburetor and the priming plug W at the top of the tank as well as the drain plug J at bottom of the tank and flush out with gasoline. The main gasoline supply tank may be cleaned by removing the drain plug and drawing off all gasoline. Strain the gas through a chamois skin when replacing.

If the tank fails to supply gasoline at high speed, be sure that the tubing connections are tight and that none are bent or partly stopped up. If gasoline is not supplied at any speed, carry out the suggestions already given and if the trouble is not remedied, look for the following things:

Leaky Float.—Remove the top of the tank by taking out the screws and running a thin-bladed knife carefully around the top between cover and tank so as to separate the shellaced gasket without damaging it. The float, which is attached to the top of the tank, should then be dipped in a pail of hot water to find if there is a leak. If a leak is found, punch two small holes in the float—one at the bottom and one in the top—so that the gasoline in the float may be drained out. Then solder up these holes and the leak, after which test again by dipping in hot water. If no bubbles are seen the float is air-tight. In soldering the float, use as little metal as possible as too much will make it heavy.

In working with the float, be careful not to bend the guide rod M, as this will retard the action of the float by hanging in the guide, thus producing the same effect as a leaky float—both of which allow gasoline to enter the engine manifold through the opening C.

Defective Flapper Valve.—A vacuum tank can be kept from working by a small particle of dirt getting in the flapper valve H. In order to tell whether the flapper valve is defective, first plug up the air vent. Then detach tubing from bottom of the tank, start the motor and apply the finger at the opening in the bottom of the tank. If suction is felt continuously, it is evident that there is a leak in the connection between the tank and the main gasoline supply or else the flapper valve is being held off its seat and is letting air into the tank instead of gasoline. This valve may usually be freed of dirt by smartly tapping the tank. If this is not effective, the valve may be inspected by first removing the tank top and the taking out the inner tank.

Vent Tube Overflow.—The vent tube allows atmospheric pressure to be maintained in the lower chamber at all times and also serves to prevent the overflow of gasoline in going down steep grades. If a little gasoline occasionally escapes through this tube, no harm will be done, and one should not worry about it. If, however, the tube overflows regularly, the air hole in the main tank filler cap is likely to be stopped up.

Leaky Valves.—Leaky valves in a vacuum tank will cause an engine to get too much gasoline on a heavy pull. Test valves by connecting up a bottle as shown in Fig. 7. Use rub-

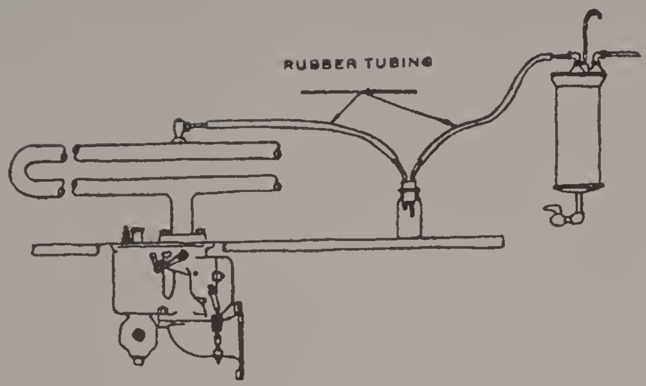


Fig. 7.—TESTING FOR LEAKY VALVES

ber tubing heavy enough not to collapse under suction and be sure that all connections are air tight. This may be assured by pouring melted wax around them. When the engine is run, gasoline will collect in the bottle if the valves are leaky.

CHAPTER VI

How to Grind and Time Valves

WHEN an engine has been in use for some time, the valves usually get leaky, especially the exhaust valves through which the hot, burnt gases pass, and the engine will not deliver its full power. The reason for this is that the surface of the valves and valve-seats become rough and pitted; and the only way to restore them to their original snug fit is to grind off this roughness and make them smooth once more.

The first step in valve grinding, of course, is to get to the valves. In a great many motors the whole set of valves may be exposed by removing the cylinder head, while others are reached by removing screw-plugs, slightly larger than the valve-heads, which are placed over each valve.

After valve-heads have been exposed, go about the grinding in a methodical way. Select the valve you will grind first, remove the spring which holds it in place, take out the valve itself, and you are ready to begin the grinding.

It is usually best to buy a grinding compound from your local garage, or you may go to your hardware store, buy some medium and fine emery dust, and use this mixed with oil or lard. This abrasive is smeared on the part of the valve to be ground and the valve then slipped back into its seat. It is then turned in its seat with an oscillating motion, either with screw-driver or with a forked grinding tool. (See Fig. 8.) Some valves have a slot for the use of a screw-driver while others have two small holes some distance apart for the use of a forked grinding tool. This forked grinding tool may be made by any farm blacksmith either in the form of a screw-driver or for use in a bitstock. A screw-driver may also be made to go in a bitstock if it is desired.

As the valve is oscillated, it is necessary to lift it from its seat occasionally so as to obtain an equal distribution of the abrasive material. Little pressure should be placed on the valve while grinding, for this will tend to give a seating which is rough and undesirable. New applications of the grinding compound should be made frequently.

When a bright ring appears all around the seat of the valve and also around the valve itself, sufficient grinding has been done, except that it is usually best to finish off the job with a very fine grinding compound. A preparation of flour emery and oil, or ground glass and oil, is usually best for this last grinding. The other valves may be ground as the first.

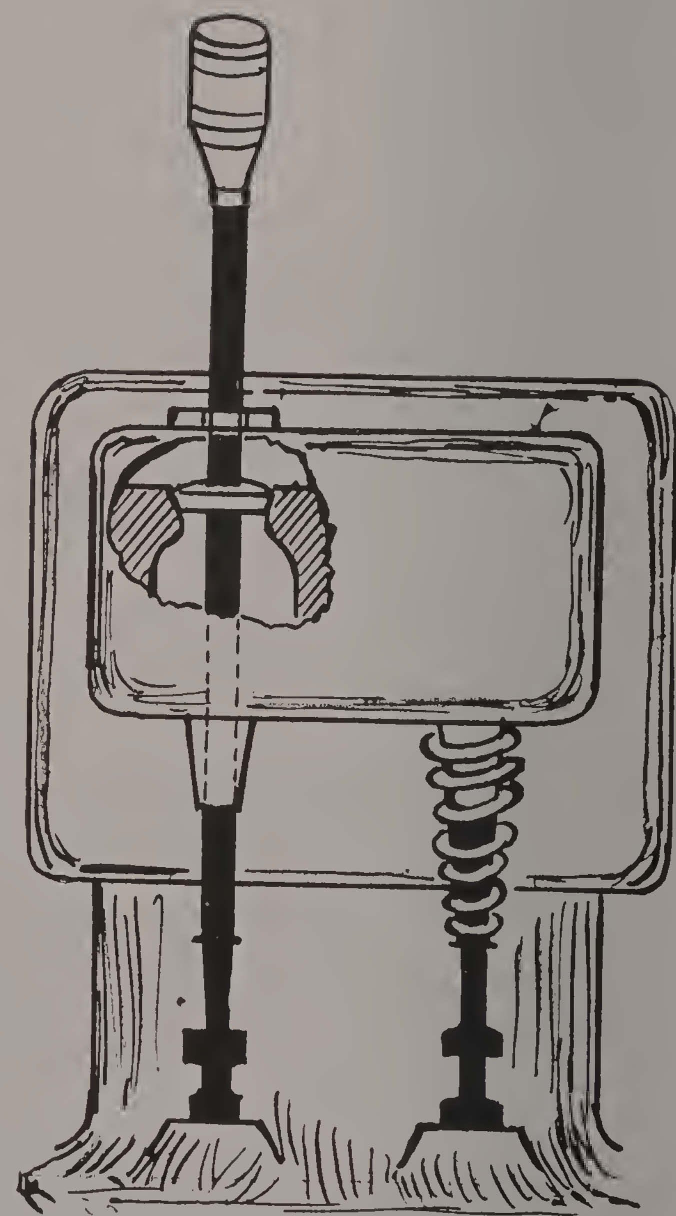


Fig. 8.—SHOWING USUAL METHOD OF GRINDING VALVES

Care should be taken to keep the grinding compound from the pistons and cylinder walls. For this reason it is well to stuff with waste or rags the ports leading from the valve chambers to the cylinder. So before removing these rags or ball of waste for reassembling the

valve mechanism, be sure to wash all the emery from the valve and valve chamber with gasoline or kerosene.

If the valves are merely ground and the motor is not otherwise dismantled, about the only valve timing necessary will be to see that there is a proper amount of clearance between the valve stems and tappets which lift the valves. During the process of grinding it may be possible to bed the valves down enough so that the stems will touch the tappets or plungers. The clearance between the valve stems and plungers, when the engine gets warmed up, should be three to four thousandths of an inch for short stem valves

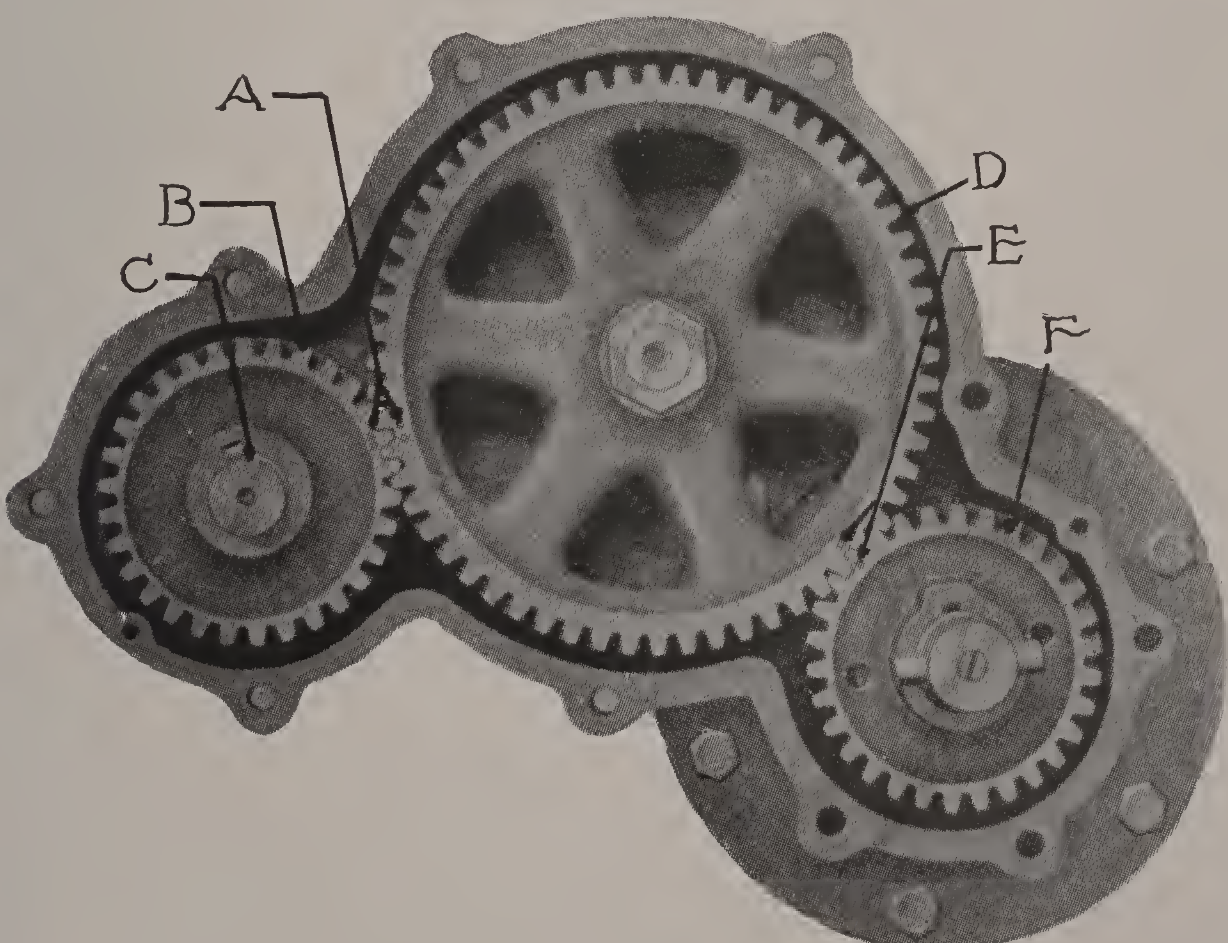


Fig. 9.

A—Punch Marks for Timing Ignition to Camshaft; B—Timer Drive Gear; C—Timer Drive Shaft; D—Camshaft Gear; E—Punch Marks for Timing Camshaft to Crankshaft; F—Crankshaft Gear.

and one one-hundredth of an inch for overhead valves; and it is usually best to make this adjustment—by the movable nuts on the plungers—after the engine has become heated. The exhaust valve will require more clearance than the intake valve because it gets hotter and therefore will expand more.

If the engine is dismantled and the timing gear disturbed, care should be exercised to replace them just as they were before the engine was taken apart. The proper relation is generally indicated by marks made on the gears by the manufacturer (see Fig. 9) of the motor. If no marks are noticed when the engine is being torn down, then the mechanic should make some for himself in order that he may be sure to replace the timing gears correctly.

The best way to do this is to bring one of the pistons, usually that in the front cylinder, to top center and see that both valves in that cylinder are closed. One tooth on the crank shaft gear is then marked with a punch or cold chisel and the slot on the large cam shaft gear in the same way. The magneto and cam shaft gears may be marked with two punch pricks or marks. When this is done, the gears may readily be replaced correctly.

CHAPTER VII

Sources of Current for Ignition

AUTOMOBILE engines get ingition current from two sources:

1. Batteries.
2. Magnetos.

Batteries are so well understood by the average auto owner that they need little space here. They have been and are still so widely used for ignition on stationary gasoline engines that they are nothing new. It usually takes from four to six thirty-ampere cells to furnish ignition for an internal combustion engine, for if too few are used the weak current will give trouble.

Every person who owns an engine using dry batteries should have a battery tester. This little instrument can be bought from any hardware store for a trifling sum and will be invaluable. Batteries should be tested before they are purchased, and if they do not test as much as twenty amperes, they should not be taken. If any battery in a series registers as low as eight amperes, it should be replaced with a new one.

Batteries should always be kept in a cool and dry place, while the switch should never be left on when the engine is not in use. In the case of stationary engines where the batteries may be disconnected and taken into the house, care should be taken to coil the wires so that none of the bare ends will form a short circuit.

Sometimes a set of batteries will "give out" when you are using the engine for important work. It is often impossible to get new batteries for several days, so here is a kink that

may help you out of trouble sometime. When the batteries go down, disconnect them all and test each one separately. Put the strongest next to the spark coil, then the next strongest, etc., till the weakest cell comes last. A dead battery next to the coil seems to absorb all the current generated by the other batteries, while if they are arranged according to their strength, the current will be augmented. Batteries will sometimes last for a long time when re-connected in this way. Always connect batteries from center to side.

Of the mechanical generators, there are two types—the oscillating magneto and the revolving armature magneto. Either of these may be high or low tension. That is, either type may be so powerful as to produce a current strong enough for ignition without the use of a spark coil, while either type may be in such form that the current delivered will require a coil to intensify it before it will give a good spark, which type is called "low tension."

A mechanical generator (Fig. 10) of electricity produces current by inductive action. It is a known fact that if insulated wire is wound around a bar of iron or steel and a current of electricity passed through it, the metal will become magnetized—that is, it will have the power to attract other pieces of iron or steel to it.

As a current of electricity flowing through a wire coiled about a bar of iron will make a magnet of it, if a magnet be inserted into an inactive coil of wire, it will generate in the coil of wire a current of electricity by a reversal of the phenomena first mentioned. In other words, a current of electricity will be produced in an insulated wire by a magnet if either of these is moved in such a way that the field of magnetic influence is traversed or cut by the wire. In a magneto (Fig. 10) a num-

ber of coils of wire are mounted on a revolving member, called armature N, which is placed between the poles of the magneto's permanent magnets or in the "electrical field" of these magnets. As the armature is turned, the windings pass through the electric field of the magnet and a current of electricity, or an "electrical impulse," is set up in the armature windings. The faster the magneto revolves the greater the number of electrical impulses produced and the stronger the current.

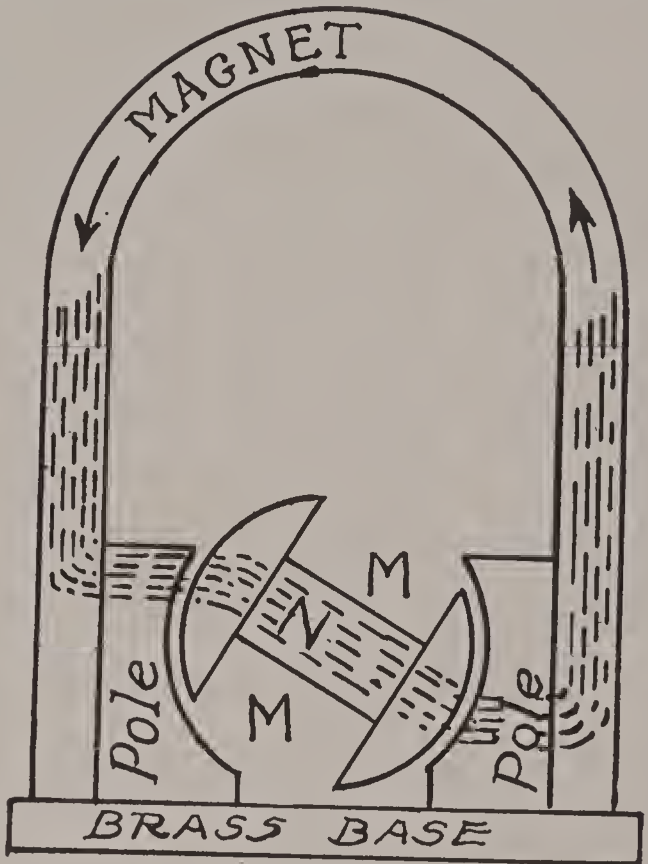


Fig. 10.
In the above Magneto outline the flow of magnetism is represented by the broken lines and arrows. In the center of the diagram and between the "poles" of the magnet is located the armature designated by the letter "N". In the completed magneto insulated wire is wound on the armature to fill the spaces marked "M". As the armature is turned the flow of magnetism through its core is broken and forced to flow through the wires wound about the sides of it. This generates an electrical impulse in the wires and gives a current for ignition the strength of which varies with the rapidity at which the armature revolves.

In the oscillating magneto, the armature is given a partial instead of a whole circuit or revolution. This magneto is so arranged that when a spark is desired the armature will be given a quick partial turn which will give a flow of electrical energy through the windings, this current being utilized in the cylinders for making a spark immediately after it is generated.

A well-designed magneto should last as long as the engine, and is one of the things the novice should not tear down. About the only attention necessary is to give the bearings a

drop of oil occasionally, keep the terminals well-connected, and the whole machine free from grease and dirt.

Before condemning a magneto or sending it to the factory for repairs, be sure the trouble is in the magneto. If in doubt about the magneto, disconnect all the wires, slightly moisten the fingers and place them on the terminals. Now have some-one crank the engine. If the magneto is all right, a smart shock will be felt.

CHAPTER VIII

Caring For Spark Coils and Vibrators

THE simple, primary spark coils used with stationary gasoline engines need very little attention. It sometimes happens that one of the wires burns in two in a coil of this kind, and in such cases it is best to send the whole unit to the maker for rewinding rather than to attempt to make the repair yourself.

Vibrating induction coils (Fig. 11) are rather more complicated, and a repairman is seldom found who thoroughly understands their care and adjustment.

If the vibrator buzzes weakly when the timer makes contact, first test the batteries to make sure there is sufficient current to operate the vibrator; or if a magneto is used, hold the moistened fingers against the magneto terminals to determine the strength of the current.

If there is plenty of current available, next examine the vibrator contact points to see if they are clean and smooth. If the points are rough and uneven, this will interfere with the proper contact and therefore with proper vibrator action. The contact points should have a true, flat surface.

The remedy for these uneven points is to remove the vibrator points and smooth them with a file, or to smooth them by passing a piece of fine emery cloth between them. As has been said before, extreme care should be taken to get these contact points perfectly level and smooth. Also file away as little of the platinum as possible.

Directly under the vibrator is the iron core of the coil.

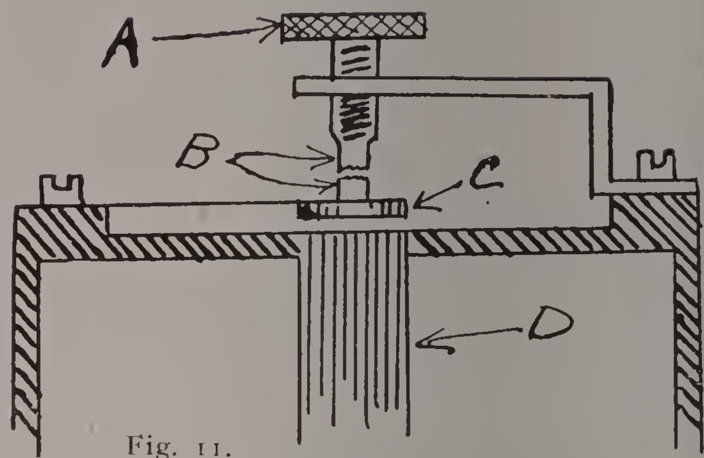


Fig. 11.
A—Adjusting Screws; B—Platinum Points (Note the uneven surfaces which should be smoothed); C—Vibrator; D—Soft Iron Core.

The coil winding is made about this core and when current is passed through the winding, the core becomes a magnet, attracts the vibrator to it, pulls the platinum points apart and thus breaks the circuit.

The farther away this vibrator is from the core the more current will be needed to operate it. The vibrator tension should be strong enough to produce a buzz but the tension should not be too great, as it will thus increase the current consumption. This will make quite a drain on the current, and if batteries are used as the cource of the current, their life will be short.

If the vibrator tends to stick, the core should be smoothed off as well as the under surface of the vibrator. This will remove any rust that may have accumulated on these surfaces. A projecting core wire sometimes interferes with proper vibrator action. Make sure the top of the core is smooth and bright.

The thing to remember, however, is that nearly all vibrator trouble comes from improperly adjusted or rough vibrator points. When all of the vibrators on a four-cylinder machine become badly worn, it is often advisable to buy and install a "master vibrator." In this case all of the old vibrators are screwed down tight, short-circuited with a short piece of copper wire, and left in their places. The master vibrator is then connected in between the magneto or batteries and the old coils—the single vibrator working for all cylinders.

CHAPTER IX

Locating Spark Plug and Engine Wiring Troubles

WHEN an engine "misses fire" or runs irregularly, the trouble may be due to one of four things, and I list them in the order of their liability:

(1) The most frequent cause of such trouble is one or more faulty *spark plugs.*

(2) The *vibrator points* may be out of adjustment or the points pitted.

(3) Some of the *ignition wiring* may be broken, disconnected or short-circuited.

(4) The *commutator* may be dirty or worn.

By far the greater portion of ignition troubles are found in the spark plugs, and one should be sure the trouble is not with them before looking after other causes.

When it is found that one or more engine cylinders are failing to fire as they should, throttle down the engine until it is turning slowly, and then test each plug separately. To do this, raise the hood of the motor, take a screwdriver and short-circuit one of the plugs to the cylinder head, as shown in Fig. 12. If the plug is working properly, the speed of the engine will immediately decrease as it is short-circuited, while it will pick up again as soon as the screwdriver is removed. Test every plug in this way till one or more is found upon which the short-circuiting has no effect. When the missing cylinders are thus located, you know where to look more definitely for the trouble.

To find out whether the missing is really due to the spark plug, unfasten the wire leading to the spark plug, hold it an eighth of an inch from the cylinder head (with the engine running on the remaining cylinders) and see if a spark passes regularly from the wire to the cylinder head. If it does, you

have located the trouble and can place the blame where it belongs—on the spark plug. If a spark does not pass from the wire to the cylinder head, then the trouble is probably due to the vibrator of the induction coil of that cylinder, the treatment of which has been discussed in a previous chapter. Or sometimes it may be due to broken wires or faulty commutator. In the latter case, however, all of the cylinders are liable to be out of commission—especially if the fault is due to a dirty or greasy commutator. If the commutator should become dirty from the accumulation of grease, remove it and clean with gasoline.

If a spark plug is found to be at fault, then it should be removed from the cylinder and the trouble given a more thorough investigation. The trouble may be due to one of several things—(1) the porcelain of the plug may be broken, (2) the electrode may be short-circuited by the collection of carbon, or (3) the points of the plug may be bent until they touch each other, or are too far apart. If the porcelain is found to be cracked or broken, the plug may as well be thrown away and a new one substituted. If the plug is merely coated with carbon, this may be removed by soaking in gasoline or kerosene and then washing the plug with a stiff brush, or scraping it with a small cloth-covered knife—the cloth being used to prevent scratching the porcelain of the plug as its insulating qualities

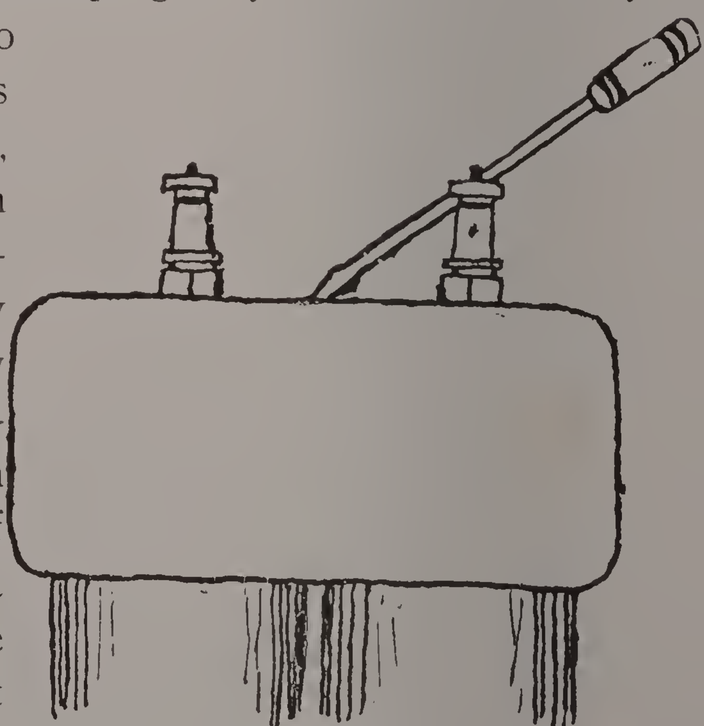


FIG. 12.
GOOD WAY TO LOCATE MISSING CYLINDERS

may be destroyed in this way. If the spark plug points are bent so they touch or are too wide apart, adjust them so that they are apart about the thickness of a worn dime.

A person owning an automobile with a high tension system of ignition will not have vibrator and commutator troubles to contend with, and there will also be a smaller amount of wire to become worn or oil-soaked. The magneto current distributor will need attention, however, and if the fault of missing is not in the spark plugs, it may usually be traced to dirty points in the distributor box.

If a screwdriver is not handy, one may often locate missing cylinders by other means. One of these is by feeling of the spark plugs to see which are hot and which are cold. If a cylinder has not been firing the plug of that cylinder will be cool in comparison with the others.

One can often tell a missing plug by removing it from the cylinder for an examination. If it has been firing the plug will be clean and fairly bright. If it has not been firing, it will be covered with grease and dirt.

All wiring connections should be kept snug and "frazzled" ends never tolerated. Also keep the wires as free from grease as possible and try to arrange them so they will not rub each other or any part of the machine. If this is done, they will be comparatively trouble-proof.

CHAPTER X

Keeping the Motor Lubricated

THE most important thing about motor operation is lubrication. If the bearings of any machine are allowed to run dry, especially in such a rapid moving machine as a gasoline motor, they will be ruined in a little while. If fed dirty oil, or too little oil, the same is true, only in less measure. It is also possible to supply a motor with too much oil causing the accumulation of carbon in the cylinders, valves, and even the

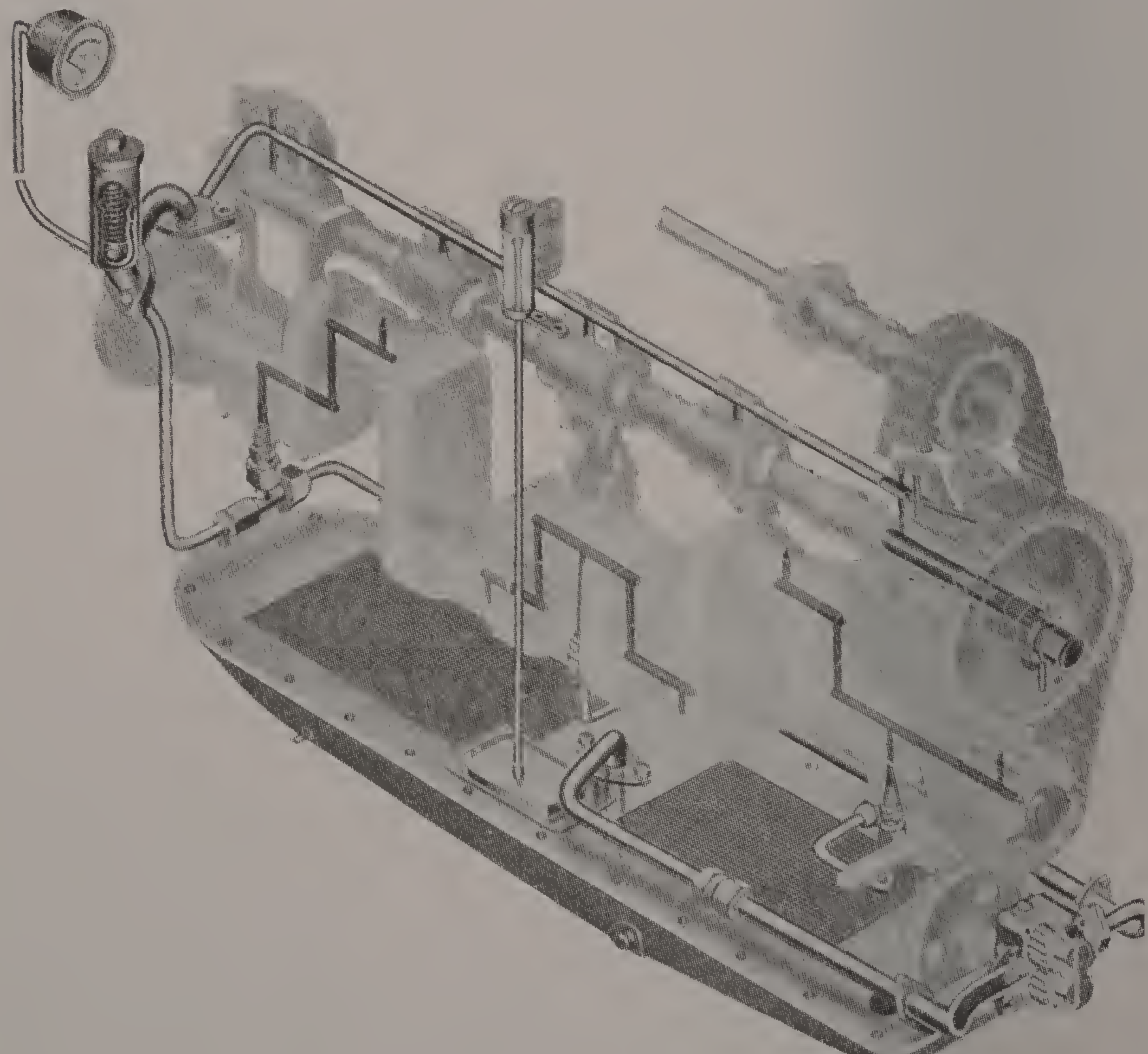


Fig. 13.—DIAGRAM FORCE-FEED LUBRICATING SYSTEM

muffler; and this is attended with a disagreeable odor and excess bluish exhaust smoke.

Lubricating systems may be divided into three classes—*gravity* oilers, *force-feed* oilers, and *splash system* oilers—or combinations of these.

The *gravity* oiler is rarely used now. It consists of an oil tank set above the engine with pipes leading to every bearing to be lubricated, while the flow of oil is regulated by check valves which may be adjusted by the operator.

The *force-feed* lubricating system (Fig. 13) seems to be gaining in favor. This consists of a tank to hold the oil, while a pump is provided to force the oil through the pipes to all bearings. Such a system, if well constructed, affords positive lubrication at all times, as it is impossible for the pipes to become stopped up and resist the flow of oil.

The *splash* oil system (Fig. 14) is the one in most common use—often in combination with the force-feed. This is so arranged that the surplus oil is stored in the crank case where

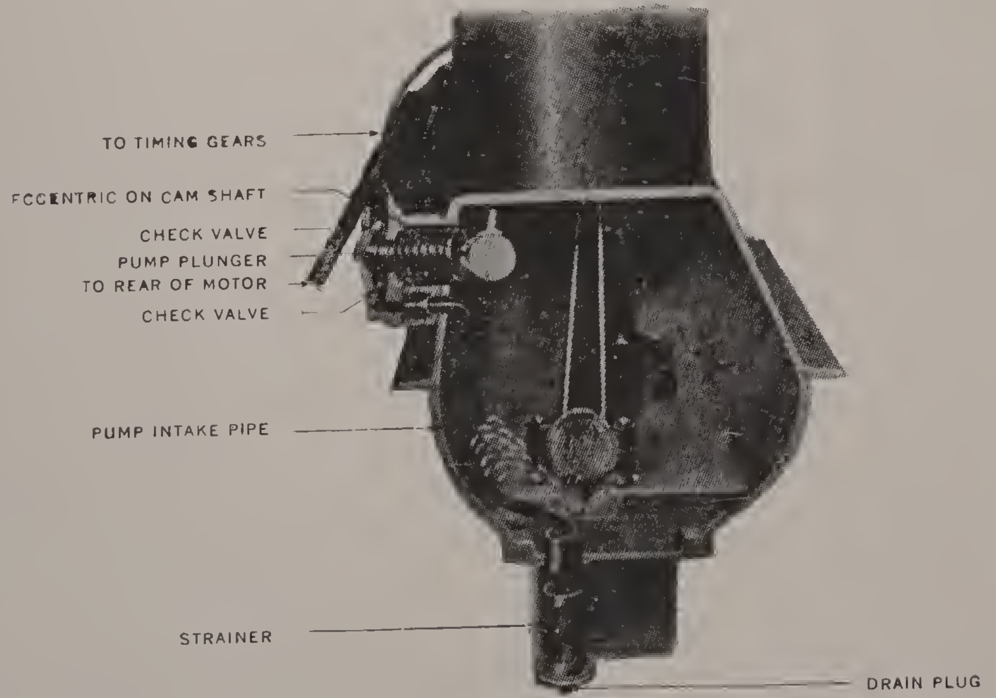


Fig. 14.—COMBINED SPLASH AND FORCE-FEED LUBRICATING SYSTEM

the connecting rods, when moving, agitate it and splash it over all the moving parts within the engine. Some motors have the flywheel within this housing which also assists in agitating and distributing the oil. This splash system is the simplest of all lubricating systems.

The success of all these systems depends on using good oil and keeping them clean. When a motor has been operated for some time and the oil used over and over again, it becomes dirty, gritty, burned, and diluted with gasoline which seeps down past the engine pistons.

When the lubricating oil in a motor becomes dirty or diluted therefore, it is well to draw out the old oil, wash out the system with kerosene, and put in new oil.

Care should be used, however, in giving the motor a kerosene bath. When the kerosene is placed in the oiling system, it should be remembered that it is *not* a lubricating oil and that the motor should be run by its own power only for an instant, and preferably by hand power or by the self-starter for a few revolutions, to wash out any dirt or sediment.

After the motor lubricating system has been washed out, drain out the kerosene very carefully and put in fresh oil. In starting the motor again, it should be remembered—especially where a force-feed oiling system is used—that it will take the new oil sometime to get to all the bearings to take the place of the oil washed out by the kerosene, so the motor should be run slowly a little while.

In force-feed systems, the pump has a fine wire screen for catching sediment. This should be examined frequently and cleaned when necessary.

Another thing that should be remembered is that "cheap" oil is not cheap at all. A machine such as an automobile motor

is a fine piece of mechanism and should be treated as such; and you can no more use poor oil and get good results than you could use coal in place of gasoline, for fuel, and get good results.

CHAPTER XI

Lengthening the Life of Bearings

IN THE automobile one finds three distinct kinds of bearings—the ordinary solid *soft metal bearing, roller bearings, and ball bearings.* Each of these have special uses. The soft metal bearings—made of brass or babbitt—are generally used for the main engine crankshaft and connecting rod bearings, and either ball bearings or roller bearings for the driving mechanism and wheel and axle bearings. Of course this arrangement is not correct in all cases, for construction differs greatly in the various cars, and where a roller bearing is used on one car, a solid or ball bearing may be employed on another.

When solid soft-metal bearings are made, allowance is made for considerable adjustment. In some cases this adjustment may be made by removing one or more small shims from between the halves of the bearings thus permitting the bearing to be drawn to a closer fit. In other cases, part of the bearing shoulders have to be filed away in order to secure adjustment. Either of these adjustments is easy, and no one should have trouble in making them.

It is well to remember, however, that in making adjustments, the replaced bolts of the bearing should be drawn tight and that the bearing should fit the shaft snugly but without undue binding. A point to be observed is to make sure that the bolts are imbedded solidly in their proper positions and that they are not raised by burrs or any particles of dirt which will flatten out when the engine is run and thus allow the bolt to slack off. To guard against this, the bolts should be struck with a hammer several times after they are tightened up and the bearing cap should be hit sharply several times with a

wooden mallet or lead hammer. Also be sure that the retaining nuts will stay in place and not slack off. The nuts used on most bearings of the motor car are of the castellated kind and can thus be held in place by cotter pins or wire.

Some of the ball bearings and roller bearings employed in automobile construction at the present time are adjustable and some are not. When the unadjustable bearings become worn, there is nothing to do but replace them with new ones. The tapered roller bearing may be adjusted, and also the ball bearings with cone and cup-shaped races. These should be inspected frequently and adjusted so that play will be eliminated, yet turn without binding.

One bearing adjustment about an automobile which seems to be neglected more than any other is that of the front wheels. You can watch the automobiles passing along any public road for a while and nine out of ten that pass will have wobbly front wheels. Jack up the front wheels of your car and see how much play they have and then adjust them by using the nuts placed inside the hub caps for this purpose.

Another thing just as important in the life of bearings as adjustment is proper lubrication. Most bearings are lubricated

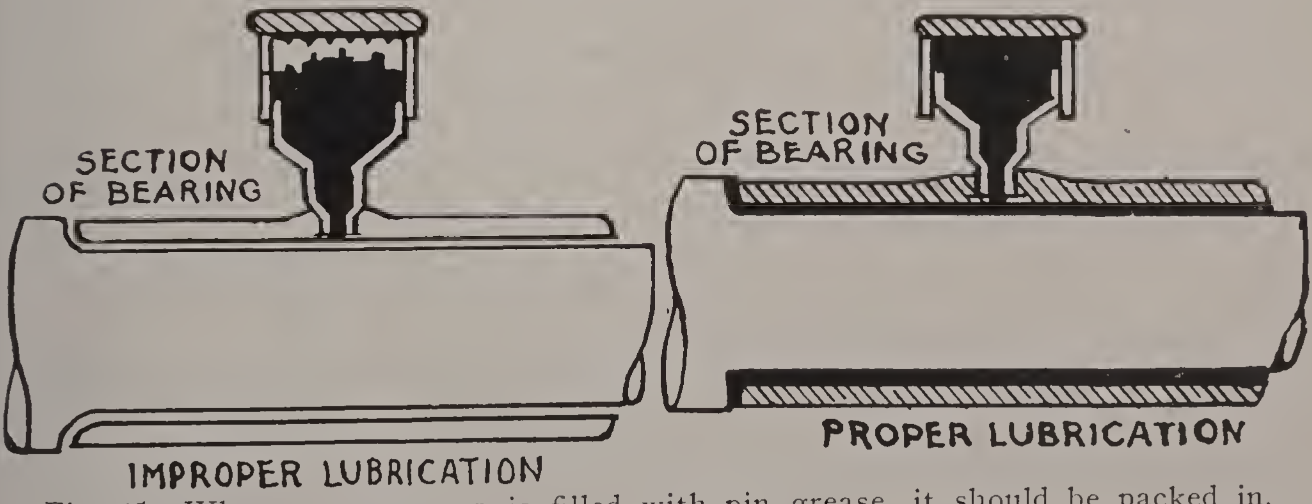


Fig. 15.—When a grease cup is filled with pin grease, it should be packed in. If this is not done, when the grease cup is screwed down the grease will then pack and the operator will be fooled into thinking he has forced grease into the bearing.

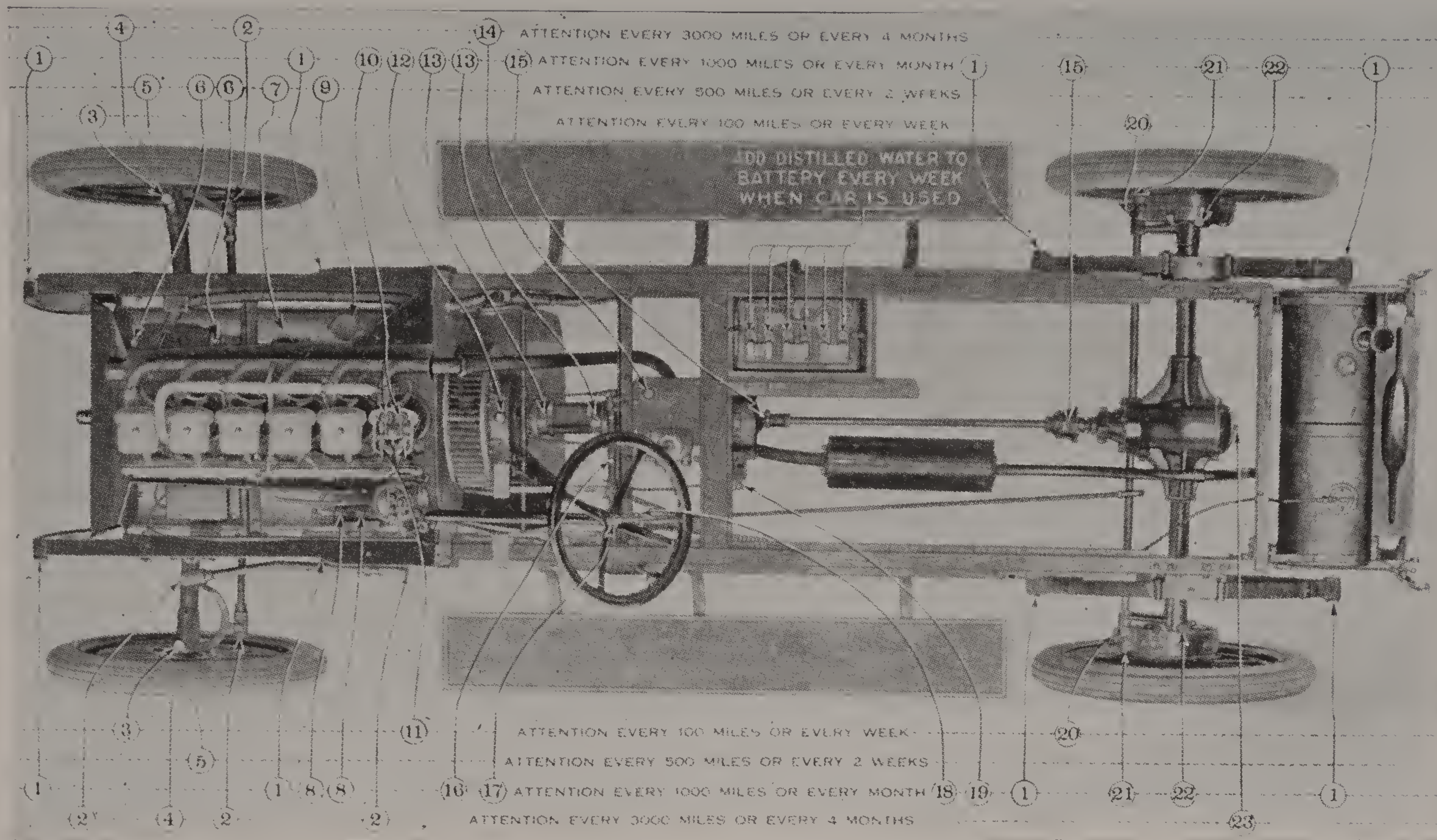
by pin grease or hard oil which is forced in by grease cups. These should be kept full at all times and screwed down often enough to force in a liberal amount of grease. Grease should never be used which contains foreign matter of any kind. Many bearings have been ruined by the use of grease which has been exposed and allowed to collect dust and dirt. Also when bearings are installed in exposed parts of motor cars, such as wheels, do not direct a stream of water directly against the bearing housing as grit may be washed into the bearing.

The auto oiling diagram and chart reproduced herewith will give the reader some idea of the many parts that constantly need lubrication. It will be well to study carefully this diagram or one dealing with your particular make of car until you have well in mind just how often each matter needs attention.

There is always a tendency to neglect many of the lesser bearings. Most people will look after the engine, the gear case and the differential but many neglect putting grease in the wheel bearings, steering knuckles, universal joints, brake linkage, spring shackle bolts, etc.

If you have been neglecting to oil your car properly, go over it now and see that every part that moves against another part is greased. And it is not enough to fill up grease cups and screw them down a few turns. One should be absolutely sure that the grease gets to the place needed. Many cars come from the factory with the oil holes in steering knuckles and shackle bolts clogged with enamel, and if there is any doubt about oil reaching these parts, remove them and thoroughly clean the oil holes with a piece of wire and a bath of kerosene.

The little things count!



—Courtesy Franklin Auto Co.

Fig. 16.—AUTO OILING DIAGRAM. (See Table Next Page)

Number on Diagram	PART	ATTENTION REQUIRED: Every Week or every 100 Miles	Every 2 Weeks or every 500 Miles	Every Month or every 1000 Miles	Every 4 Months or every 3000 Miles
1	Spring Pivot Bolt			Graphite Gr	
2	Steering Connections				Graphite Gr
3	Steering Yoke Bolts	Graphite Gr			
4	Front Hub Caps				Cup Grease
5	Oil Hole in Front Hubs		Gas. Eng. Oil		
6	Starter Bearings		Gas. Eng. Oil		
7	Tire Pump		Gas. Eng. Oil		
8	Steering Device Oil Cups			Gas. Eng. Oil	
9	Engine Base	Change oil after first 400 miles; thereafter, every 600 miles			
10	Valve Stems			Gas. Eng. Oil	
11	Lifter Rods	Gas. Eng. Oil			
12	Clutch	Change oil after first 400 miles; thereafter, every 800 miles			
13	Front Universal Joints			Graphite Gr	
14	Transmission				600-W
15	Rear Universal Joints			Graphite Gr	
16	Pedal Support Shaft			Gas. Eng. Oil	
17	Steering Wheel			Gas. Eng. Oil	
18	Hand Brake Lever Shaft			Cup Grease	
19	Service Brake Hanger			Cup Grease	
20	Emergency Brake Links	Gas. Eng. Oil			
21	Emergency Brake Shaft			Gas. Eng. Oil	
22	Rear Wheel Bearings			Cup Grease	
23	Rear Axle Housing				600-W
1	Spring Pivot Bolt after 11,700 cars			*Gas. Eng. Oil	
3	Steering Yoke Bolts " " "		*Gas. Eng. Oil		
18	H'd B'ke Lever Shaft " " "			*Gas. Eng. Oil	
19	Service Brake Hanger " " "			*Gas. Eng. Oil	
24	Clutch Trunnion " " "			*Gas. Eng. Oil	

—Courtesy Franklin Auto Co.

AUTO OILING CHART (See Diagram Preceding Page)

CHAPTER XII

How to Treat the Clutch

A CLUTCH is a mechanical device by which the motor of an automobile is connected to the driving mechanism. By engaging or disengaging the clutch, an automobile may be stopped at will while the motor is allowed to run.

Now why is it necessary for an automobile to have a clutch?

Let us see. A clutch is not necessary on a steam engine or an electric motor, because both of these power plants draw their energy from other sources and are therefore able to deliver their rated horse-power instantly and can start under load. The automobile engine is different; it generates its own power by internal combustion, as we have already learned, and the power of the engine depends to a great extent on its speed. It is therefore obvious that it can't be started under load, as it has to be started by hand or self-starter and allowed to gain speed.

Practically all automobile clutches are of the frictional type. That is to say, two surfaces—one fastened to the propelling mechanism and one to the power plant—are arranged so that at the will of the operator they may be "engaged" or brought into contact with each other or "disengaged" or separated from each other. When the member of the clutch that is attached to the automobile motor is brought into contact with the member that is attached to the driving mechanism, the rotary motion of the one is transmitted to the other, until finally both members become firmly engaged and turn as one.

At the present time there are two principal types of clutches—the cone clutch (Fig. 17) and the multiple clutch (Fig. 18). Both give good results. The cone clutch is usually

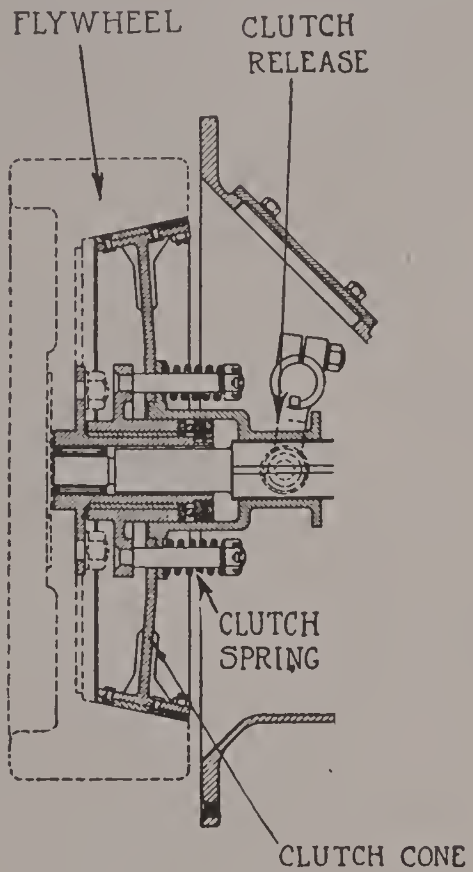


Fig. 17.—CONE CLUTCH

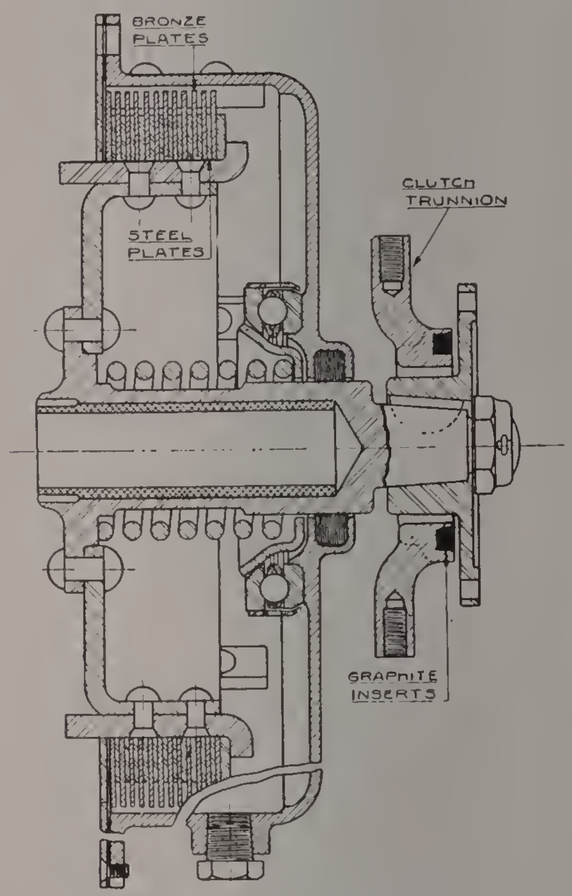


Fig. 18—MULTIPLE CLUTCH

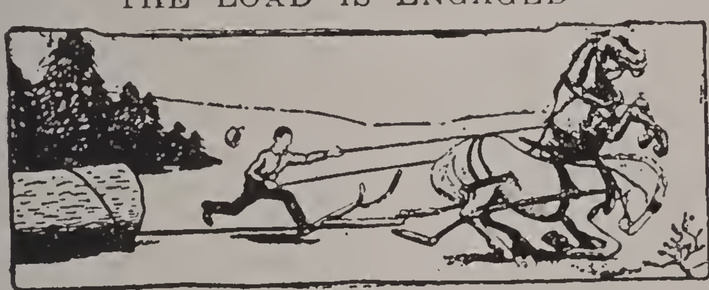
faced with leather or a combination of leather and cork, while the multiple disk has no facing whatever and runs in an oil bath.

Another method of transmitting power is by what is known as planetary gears. This system is very simple in operation but rather complicated in construction. There are so many bushings and bearings in this type of transmission that it usually wears out quickly and has been discarded by most manufacturers. There is one well-known make on which this type of transmission is standard equipment, however.

If treated right, the clutch rarely gives any trouble except in the course of time it will have to be refaced or adjusted to take up any wear. The instruction book of your particular make of car will give you detailed information for doing this.

But "how to treat the clutch" is the most important thing, and about the whole story is told by the accompanying drawing (Fig. 19) which illustrates in the case of horses the same principle we have to deal with in starting automobiles. If the motor is speeded up too much and the clutch abruptly engaged, there is not so much danger of permanently damaging the clutch as there is of breaking some other part of the car —usually some of the small drive pinons.

SPEEDING UP THE POWER BEFORE THE LOAD IS ENGAGED—



AND THE EFFECT

Remember therefore not to race the motor and to engage the clutch *gradually*. Do not let your car start with a jerk, for this will do more damage than several miles of actual road service. The trick of engaging the clutch properly is hard to learn, and differs on every car, but by a little thought and watchful practice, it can be learned.

CHAPTER XIII

Making the Gear Shifts Right

IN CHANGING gears or making gear shifts, there is always danger of "stripping" the gears that serve as transmission members—that is, danger of breaking off some of the teeth from the gears. It will be well therefore for every automobile operator to learn some rules on correct gear shifting.

The automobile motor gets it power from speed—the faster it runs the more power developed. For this reason, in starting a car, climbing a very steep hill, or going through a muddy place, a driver should use "low gear." When "low gear" is used, the crankshaft of the engine makes several revolutions to every revolution of the automobile drive shaft. When you go to "second speed" the speed ratio between engine and drive shaft is reduced; and when a change is made to "high" the ratio is reduced still more—the drive shaft usually running at the same speed as does the motor. From this it should not be understood, however, that the rear wheels revolve every time the engine crankshaft does, for the ratio is still further reduced by the rear-axle gears which will be discussed later.

Now for some rules to go by. We have already learned that the clutch is the connecting link between the engine and the driving mechanism. We use the clutch in starting or stopping a car and for disconnecting the engine from the driving mechanism to make gear changes. Here are five rules to be remembered:

1. *Never try to make gear changes with the clutch engaged.*

2. *In starting a car, first set the gears for low speed and then gently engage the clutch.*

3. *In changing from first to second speed, disengage the clutch, slow the engine and after hesitating an instant make the change.* In making this change it will have to be remembered that the engine will turn slower in proportion to the drive shaft speed, and this ratio should be judged as nearly as possible by the ear before changing the gears. This will also apply when changing from second speed to high speed.

4. *In changing from high speed to a lower speed, slip the gear shift lever in neutral, speed up the engine and engage the clutch for an instant, after which release the clutch end shift to the lower speed.* The whole problem in making gear shifts correctly is in getting the gears to turn in proper ratio to each other before an attempt is made to shift them.

Let me illustrate more fully what is meant. Figure 20, shown herewith, is a diagram showing the gears used in changing the speed of the modern automobile with sliding gear transmission. When the engine of a car is started and the clutch A in the diagram is engaged with the engine flywheel (the engine flywheel is not shown in the illustration) the clutch A revolves, turning with it the gear I, which is in mesh with gear B. This of course causes B to revolve and also shaft D on which gears C, E, and F are fastened.

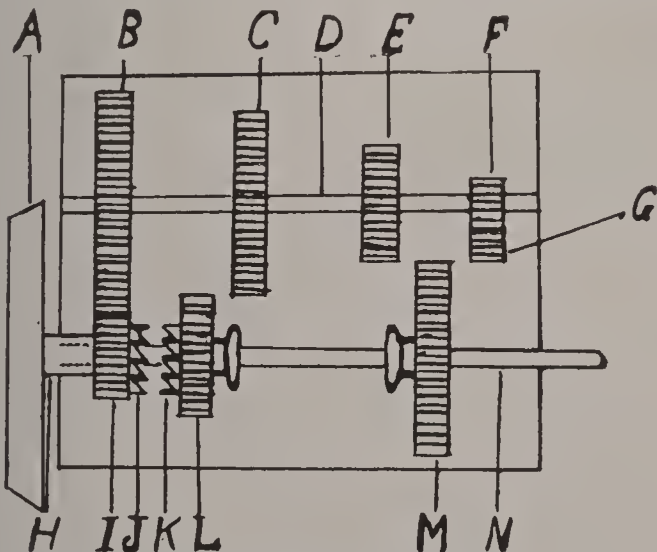


Fig. 20.—DIAGRAM OF AUTO SPEED CHANGE GEARS

Now, then, as the drawing is shown, the gears are in neutral and the car will not move forward when the clutch is engaged. The clutch shaft H is hollow and the main axle shaft N extends into it. These shafts are not keyed together and one may therefore turn independently of the other. When the clutch A and the shaft H turn therefore, the main drive shaft N running to the rear wheels and the cogs L and M, fastened on this shaft, are still.

Shaft N is square, except the end entering shaft H, and the cogs L and M may be moved up and down on this shaft by the gear shift lever. When you want to start a car you therefore throw out the clutch and wait a few seconds for the clutch and gears to stop turning. Then slip the gear shift lever into low speed position which brings gears E and M into mesh. When you let back the clutch pedal which causes clutch A to engage with the engine flywheel, gear I is turned, which turns gear B, which turns gear E, which turns gear M, which turns the main drive shaft and causes the car to move forward.

After the car gains some headway, the clutch is thrown out again, the engine slowed, the gear shift lever pushed to neutral and held for just an instant, and then pushed to second speed, which engages gears C and L. The clutch is then dropped back which causes the whole mechanism to turn, the large gear C driving the small gear L at a greater speed causing the car to move forward faster.

When the car gains more headway in second speed, the clutch pedal is again depressed, the engine slowed, and the gear shift lever carried over to third speed or "high" gear. This brings the slotted teeth J and K together and when the clutch is engaged the drive shaft turns over

every time the engine does and shafts H and N are locked together with no gears in mesh.

To reverse a car, the gear shift lever is placed in reverse position, which engages gear M with gear G. Gear G is engaged with gear F at all times; and the introduction

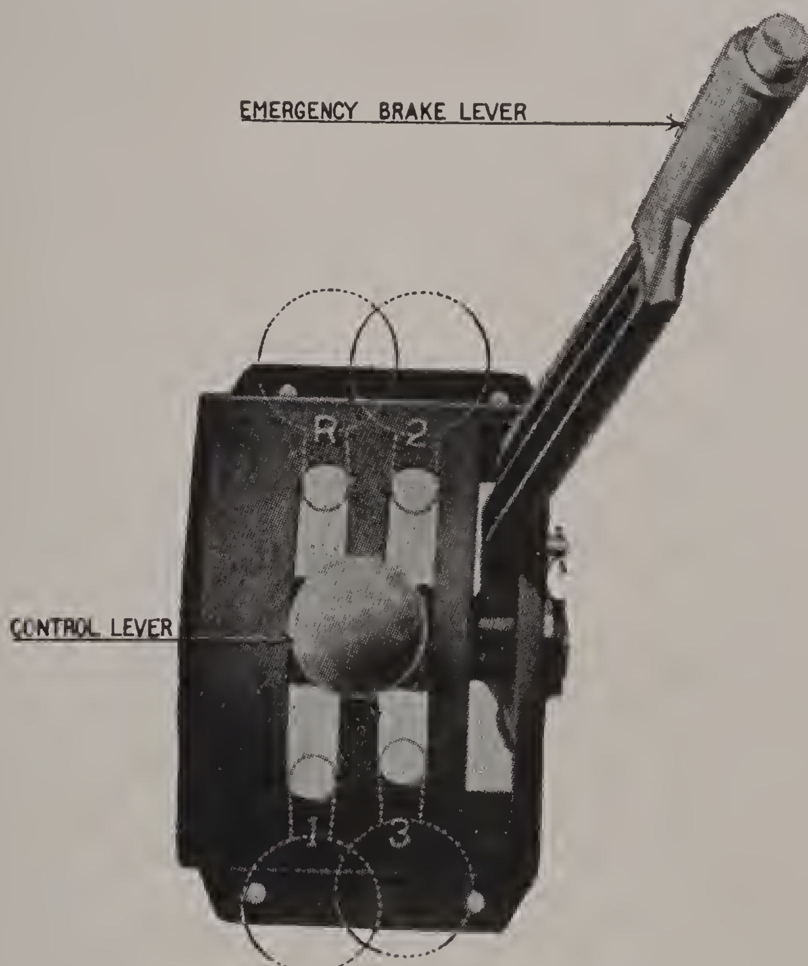


Fig. 21.—HAND CONTROL LEVERS

of this third gear G gives a reverse motion like crossing the belt on a threshing machine.

Figure 21 shows a modern control lever or gear shift lever and how it is used. Position R is reverse, position 1 first speed, position 2 second speed, and position 3 third speed or high gear. Figure 22 also shows a gear and clutch assembly where the relation of gear shift lever and clutch to the gears themselves is more evident.

Going back to Figure 17, let's study gear shifting a little more. I have already said that gear changes should be made when the gears are running in proper ratio to each other; and I want to explain this more fully.

When a car is stopped, the gears are usually set in

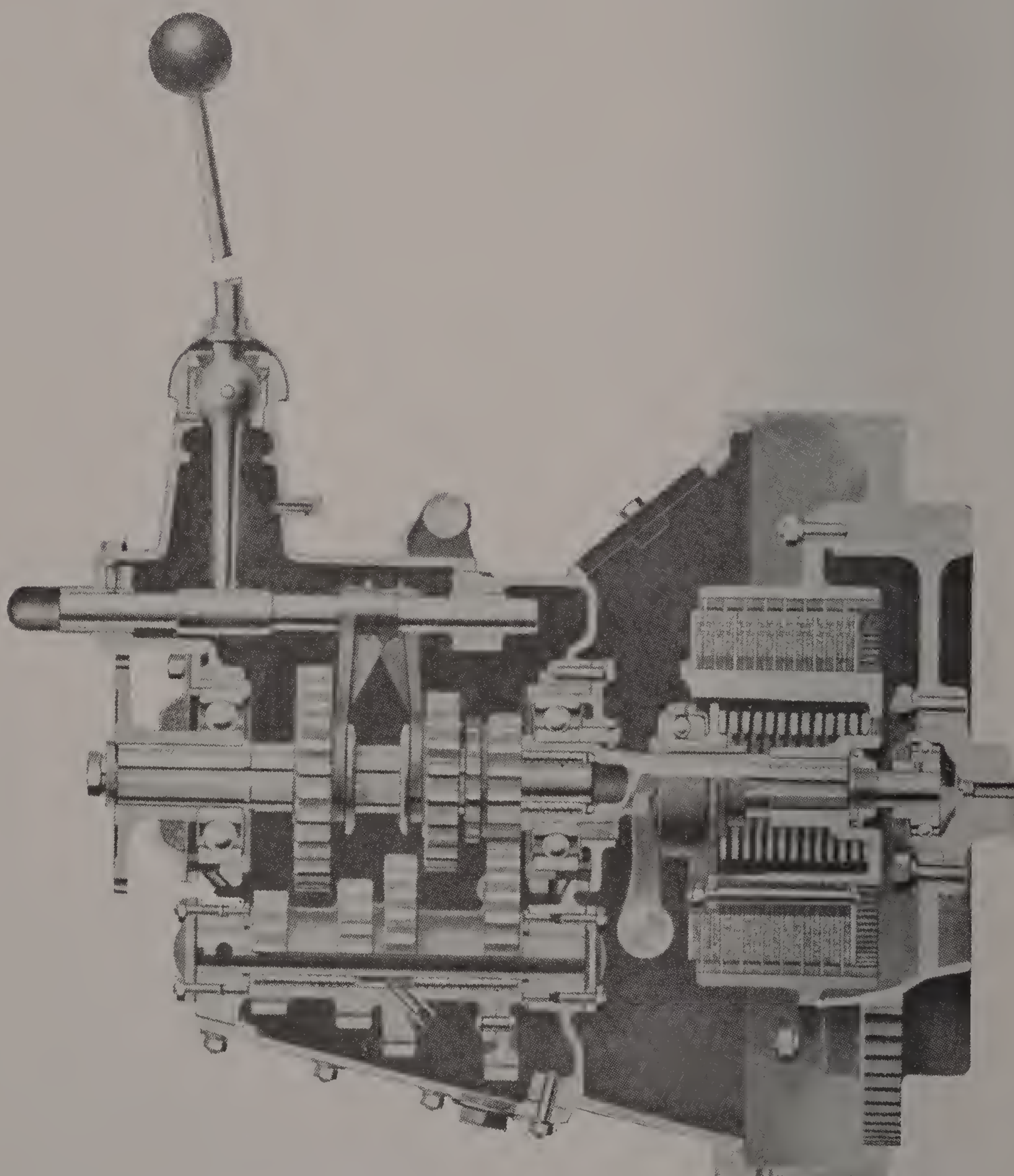


Fig. 22.—SECTIONAL VIEW OF A STANDARD CLUTCH AND GEARSET

neutral and the clutch allowed to engage. When the engine is cranked, therefore the clutch, gear I, and all the gears on shaft D are set in motion. When preparing to start the car therefore, the clutch should be depressed and all the gears in the transmission allowed to come to rest before an attempt is made to engage the slow speed gears. If one simply depresses the clutch and tries quickly to engage the gears while the clutch and gears on shaft D are still spinning, the rasping noise that will ensue may be heard quite a distance. In other words, the gears are not turning in proper ratio to each other and therefore cannot be engaged noiselessly—for one gear is motionless and the other is spinning and there is bound to be friction when they are brought together. Low speed and reverse gears should not be engaged after the clutch pedal is depressed until the clutch has time to stop spinning.

When one wishes to change from low speed to intermediate, two gears must be meshed which are in motion, instead of two which are standing still. If the engine of the car is making 600 revolutions per minute, the shaft D will be making about 200 per minute which will make the gear N turn over about 75 times a minute. To go to second speed therefore, gear L, which is revolving 75 times a minute must be meshed with one revolving 200 times a minute. And not only this, but gear C is much larger than gear L and if they were revolving at the same speed gear C would put two teeth past the point of contact to gear L's one. To mesh properly gear C should be slowed until it turns at about 35 or 40 revolutions per minute. To get gear C turning at the right speed, the driver simply throws out the clutch of the car and waits to make the gear change until his ear tells him that the proper speed has been reached.

This will take practice, but it may be mastered to such a degree that a person standing by cannot hear when the gear change is made. This will also apply when changing from second speed to high gear.

5. *Never engage the reverse gear when the car is in forward motion, as the gears will invariably be stripped.*

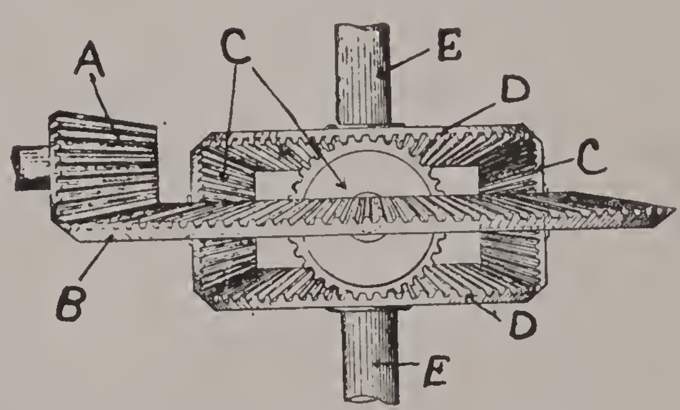
It is rather difficult to shift gears from a high speed to a low speed without making a great deal of noise. To make this change correctly, the speed of the car must be comparatively slow and the speed of the engine and clutch considerably increased. A satisfactory way to do this is to shift the gears from a high speed to neutral, speed up the engine and engage the clutch while gears are in neutral, and then shift to the lower gear while the clutch is spinning and the car moving slowly.

CHAPTER XIV

How Differentials Work

THOUGH unseen, one of the most important units of the automobile driving system is the differential gear. It is comparatively simple and with proper care gives little trouble, but without such a gear one could not turn corners with a car.

When turning corners with a four-wheel vehicle, the wheels on the outside of the circle turn at a greater speed than do the wheels on the inside because they are describing a larger arc. On a horse-drawn vehicle all the wheels are independent of each other and may revolve at different speeds when necessary. In the automobile, different conditions prevail, and while the front wheels are mounted independently, the driving wheels must be connected so that each will receive its share of the power generated by the engine.



Rig. 23.—A—Driving Pinion; B—Driving Gear; C—Differential Pinions; D—Axle Gears.

In order to let the rear wheels of an automobile turn at varying speeds when corners are turned, what is known as a differential gear is used. From the illustration herewith (Fig. 23) it will be noticed that the axle is in two parts and that the inner end of each part carries a bevel gear. The main driving gear is mounted independently of the axles and is coupled to them by means of four small pinions.

Now then, look at the illustration and assume that the power is being applied to the drive pinion. It is easy to see that if the resistance is the same on both axles the whole driv-

ing mechanism will turn as one unit. If, however, the resistance of the shafts vary, the differential pinions will not only turn around on their studs but at the same time turn around the bevel gear of the slower turning axle while the other axle which is free to turn will be revolved at a faster rate than usual. This accounts for the fact that if you get one of the rear wheels of your car in a bottomless mudhole and apply the power, the wheel in the mudhole will spin very rapidly while the wheel on solid ground will remain motionless.

You will see from the above paragraph that the differential gear is very flexible. One wheel may stop altogether while the other continues to revolve or both wheels may continue to turn at only slightly different speeds when a slight curve is turned on the road somewhere. It is on the job at all times and really steers the rear wheels of your car for you.

When on the road this part of your car has a great deal of work to do and should therefore be kept well lubricated. All differential and driving gear housings have a screw plug which may be removed to insert pin grease. It will pay every automobile owner to buy a "grease gun" for putting in this grease and then use it frequently.

CHAPTER XV

Caring for Starting and Lighting Systems

SO WELL built are the present electric lighting and starting systems that they are almost "fool proof." By this is meant that they are nearly automatic and will almost care for themselves. There is little likelihood of the starting motor or the current generator getting out of order, and the wiring is not likely to give any trouble, at least for a few years, when the rubber insulation may become worn or decayed from exposure, and need to be renewed.

In the housings of the generator and motor, oil holes will be found and each one of these should receive four or five drops of good lubricating oil for every three hundred miles a car is run.

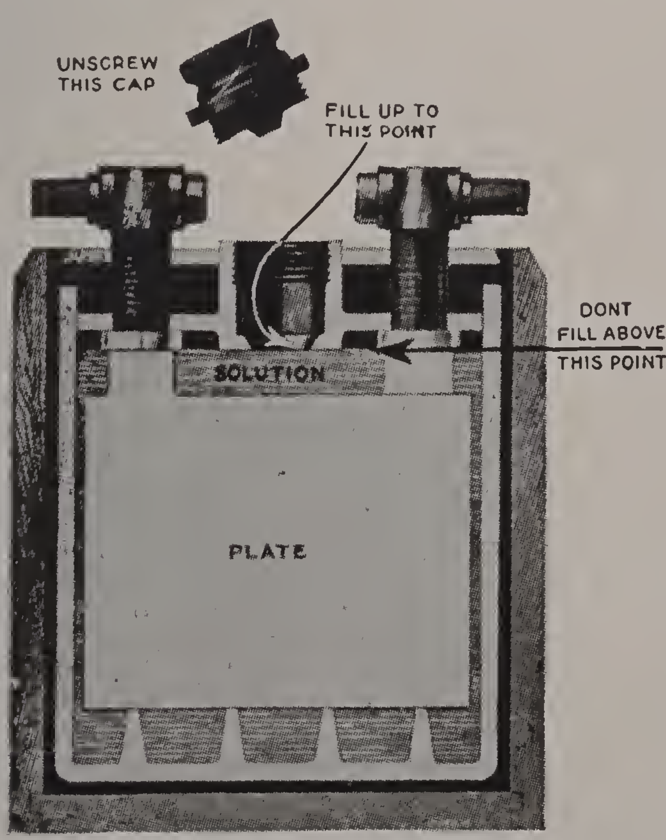


Fig. 24.—SECTION OF STORAGE BATTERY

Eliminating the things mentioned above, it may be said that the care of electric lighting and starting system is merely the care of the storage batteries, and the discussion will be confined to this particular point.

A storage battery is made up of cells (Fig. 24), each one of which contains a positive (brown) and a negative (gray) plate made of compounds of lead and immersed in a solution of sulphuric acid and water

(electrolyte). Without going into the principle upon which storage batteries operate, it will be sufficient to say here that these cells have the capacity of absorbing and holding a current of electricity when it is passed into them. In other words, they are able to *store* current and deliver it up again when needed. Hence the name "storage battery."

When the motor of your automobile is running, the generator of the car's electric system is made to revolve and thus generates an electric current. This is taken up by the storage battery for the use of starting motor and lights and is delivered to them when needed—which may be several days after storage or right away. A good storage battery will hold current a month or more if it is not drawn on or short-circuited.

It is useless to give directions for storing automobile storage batteries in winter, for nearly everywhere cars are now used the year around. Care should be taken, however, to keep the batteries well charged in cold weather to prevent freezing. If this is done, no automobile battery is likely to be damaged by cold. This is especially true, since most cars are moderately well housed.

It will be necessary to add water to the electrolyte in the cells occasionally, because the water evaporates. The water added should be distilled water, melted artificial ice water, or fresh rain water—enough of which should be poured in to raise the electrolyte above the battery plates. *Never add acid,* because this does not evaporate.

It is sometimes necessary, however, to add more electrolyte to the battery cells, as when some has been spilled, a cell broken, or the old electrolyte poured out in order to remove sediment which has collected in the bottom of the cells. This latter is one of the most common reasons, because sediment should

never be allowed to collect till it touches the bottom of the cell plates.

If one is going to mix his own electrolyte, he should buy a hydrometer syringe for measuring the specific gravity of fluids. One of these will cost about a dollar. It is also useful in testing batteries.

To make electrolyte, mix chemically pure sulphuric acid of 1.835 specific gravity with distilled water at the rate of two (2) parts of acid to five (5) parts of water, by volume. These liquids should be mixed in a glass or earthenware vessel and *the acid must always be poured slowly into the water* and not the water into the acid.

The condition of the storage battery may be determined by the use of a hydrometer syringe (Fig. 2). Electrolyte from a fully charged battery will have a specific gravity of 1.275 to 1.300 and shows that a battery is in good condition. If about half charged, the specific gravity will be about 1.200—while if it tests lower than 1.150 it indicates that the battery is completely discharged.

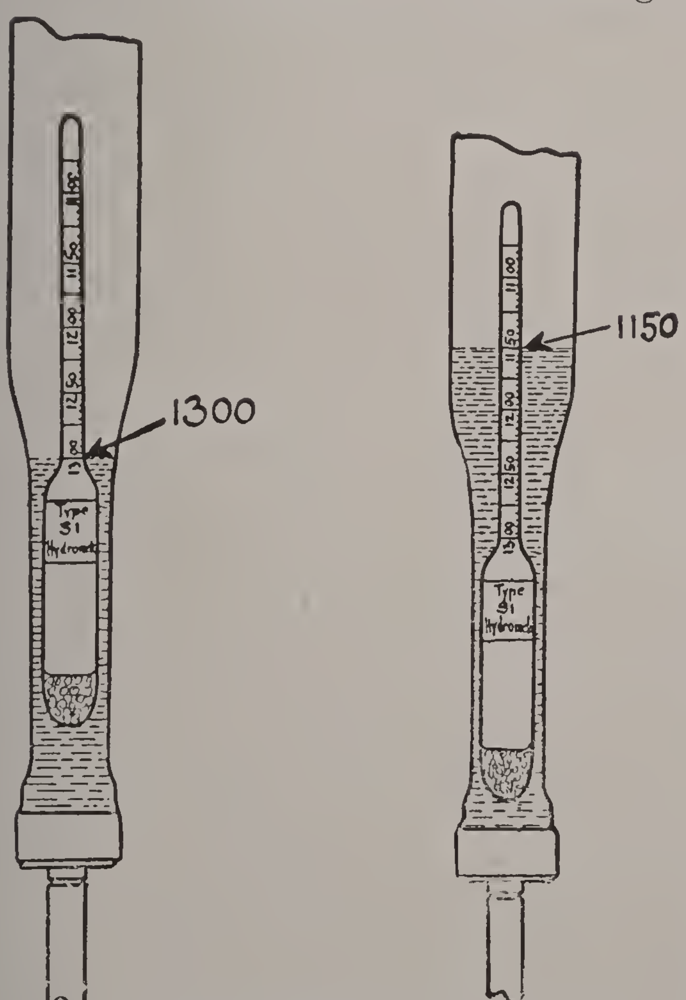


Fig. 25.—READING A HYDROMETER SYRINGE

One should be careful to keep all cell filling plugs tightly in place to keep the electrolyte from splashing out over the battery tops. Care should also be taken to

avoid spilling this solution on the cell tops when filling them. If some of the solution is spilled and the tops and connections begin to corrode brush them over lightly with vaseline.

CHAPTER XVI

How to Use and Care for Brakes

THE brakes are such an important part of a car that they deserve special treatment. If you have to start out on a hurried trip and do not have time to examine the entire car, better let the engine go and look over the brakes. The engine should at least be in fair condition to get you anywhere, but if your brakes are bad, it may get you too far.

The manufacturer recognizes the importance of brakes and has not only made them ample in size but has designed them so as to be protected from grit and dust and so that dragging will be prevented. Brakes on modern cars therefore are sufficient for all ordinary purposes if properly cared for.

The car-owner should understand first of all that every car has two sets of brakes which operate independently of each other. Very often a car goes over an embankment or into a ditch because the owner or driver did not know there were two independent braking systems on his car. One went wrong so he thought there was no method of stopping the car.

In fact, cars have three methods of braking. One is the foot brake, another the emergency brake, and the third is the engine. Most people regard the engine as something that speeds a car instead of slowing it and this is generally true. But if one will arrange the throttle adjustment so that all the gasoline may be cut off, the compression of the engine will act as a brake in going down hill. And if still greater braking power is necessary, a car may be thrown in low gear, when the braking power of the engine will be very great.

In fact, in ordinary driving, a car may be controlled by using the brakes very little. Cut off all gasoline and let the engine coast down hills against compression, using the foot-

brake as much as is necessary for perfect control; and few hills will require the use of brakes at all. The same thing is true in bringing a car to a stop: cut off the gasoline ahead of time and let the car coast to a standstill as nearly as possible.

On long hills where it is necessary to use the brakes (and no driver should hesitate to use them when it *is* necessary) the driver should learn to use first one set and then the other. Under constant use brakes become hot and their fabric lining

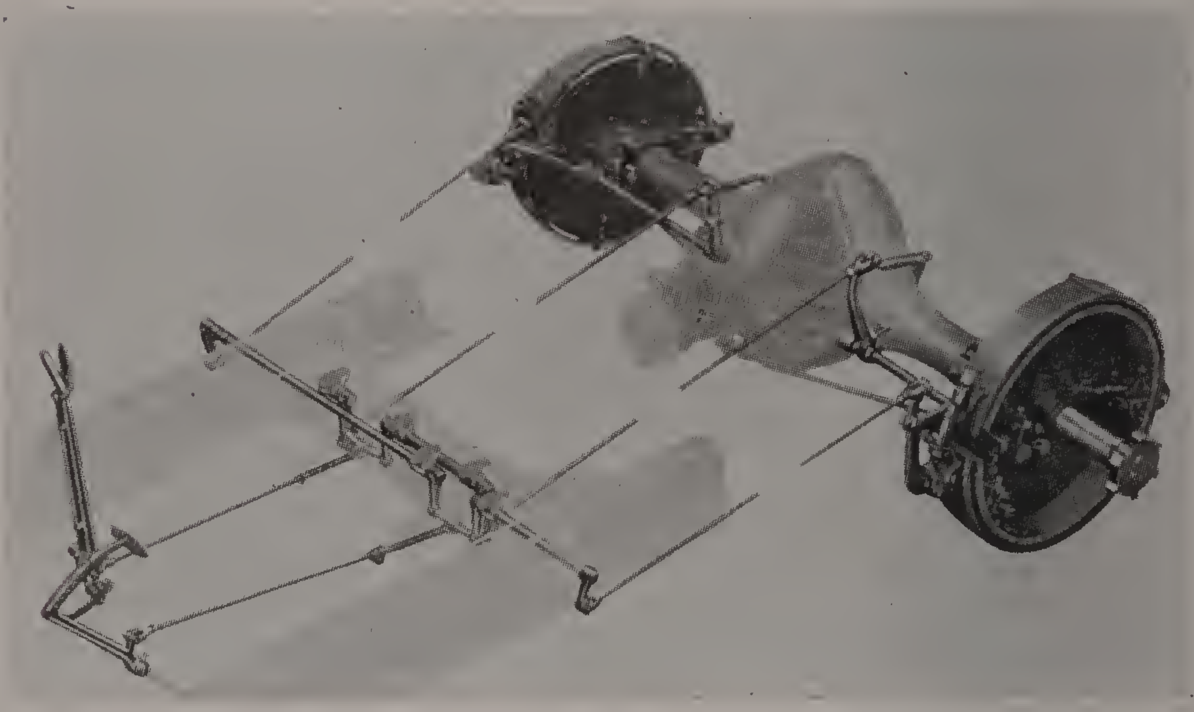


Fig. 26.—MODERN BRAKING SYSTEM

will burn out. Therefore alternating the sets used under heavy duty will prevent overheating.

There is another thing besides burning out that causes brakes to fail, and this is the collection or the inadvisable application of oil on the brake drums. Sometimes this is caused by oil working out at each end of the rear-axle housing or sometimes the car-owner may have become too enthusiastic about lubrication and oiled everything "in sight."

The braking surfaces should not be oiled intentionally, and

if oil works out of the axle housing onto the drums, the probability is that the oil level in the differential case is kept too high or that the felt packing at each end of the axle is inadequate. Lower the oil level or repack the axle housing ends as may be necessary.

While oil on the brake bands and drums is not wanted, it should not be taken for granted that brake linkage, levers, etc., should not have oil—for this is highly desirable. Such oiling not only reduces wear, but will eliminate many would-be squeaks.

Another cause of brake failure is due to the linings wearing thin and thus allowing the rivets with which they are fastened to the bands to come in contact with the drums. This "scores" or grooves the drums and greatly reduces their efficiency. When brake band linings begin to show much wear therefore, it is well to have new fabric put in.

The usual arrangement of brakes on the modern car is (1) a set of foot-brakes—one brake on each rear wheel—which contract on the brake-drums and (2) one set of hand-brakes—one brake on each rear wheel—which expand inside the brake drums. The foot-brake is the one most used while on the road, and the hand-brake is largely used for locking a car when it is left standing, but it may be used alternately with the foot-brake on long grades, as I have already mentioned. Or in case of an emergency, it may be used to stop quickly. The driver should not depend on the emergency brake for making a quick stop, however, and thereby let his service brake get in bad shape. Keep them both in good working order.

The adjustment of brakes is very simple. They have an adjusting arrangement at each brake and also on the brake linkage. In making brake adjustments, these facts should be kept in mind: (1) that brake bands should be clear of drums

when not applied; and (2) that each brake drum should be gripped with an equal pressure. The adjusting bar swung under every car will take care of some variation in adjustment, but it should not be expected to do it all. A good way to equalize the adjustment is to jack up both rear wheels and test out the brakes to see which acts the more quickly. When this is determined, adjustment may be made intelligently. Unequalized brakes cause skidding.

CHAPTER XVII

How to Save Tire Money

THE cost of tires is one of the very largest items in the automobile's expense account. When some people get a new car they firmly believe that tire trouble is unavoidable, and therefore do not try to care for the tires properly and get as much service as possible. If a neighbor gets good service from his automobile tires, he is "lucky." If another neighbor gets poor service from the same kind of tires, he is "unlucky." As a matter of fact, there is no luck at all to the service given.

There are just three common tire enemies—water, light, wear. Let us consider the relation of these things to tire life.

The walls or substantial inner portions of the automobile tire are largely composed of cotton fabric. When tires are new, this fabric is held together and completely covered with a coat of rubber which is of course waterproof. As the tires are used, they hit obstructions such as sharp rocks, bottles, cans, pieces of glass, etc., which cut through the outer coating of rubber—and sometimes well into the fabric itself—and leave the cloth exposed. Then moisture enters and decay sets in; and later when the car hits some rock or bump, the tire blows out.

One of the first things an automobile owner ought to buy therefore is a small vulcanizer so that such cuts as have been indicated may be promptly repaired before decay sets in. There are also some putty-like preparations on the market which do very well for filling such cuts as these.

Then *light* is another great cause of tire damage—and heat goes with it. The garage where a car is stored when not in use should be dark, cool, and dry. Light seems to start a process of decay in the rubber of a tire and when frequently ex-

posed to direct sunlight for long periods of time, the rubber loses its vitality and becomes hard and devoid of resiliency. When a car is to be left standing out for some time, leave it under shade, if possible. If this can't be done, spread a robe or something similar over the tires exposed to direct sunlight. Spare tires usually get the worst treatment and covers for spare tires will pay well.

Of course, tires will wear out, even with the best of care. It is natural that they should wear to a certain extent; but it is unnatural for them to wear out as rapidly as a great many drivers think. This question of wear is so important that I believe it will be well to give a few suggestions as to how it may be reduced a great deal:—

1. *Keep tires inflated to the pressure* recommended by the manufacturers except when they become badly worn. To this end, buy a tire pressure guage and use it. Under-inflated tires not only wear out quickly but increase the gasoline consumption because of their greater road friction. It should be remembered, however, that inflation should be a little less in hot weather as heat causes the air in tires to expand—causing blow-outs if pumped too tight.

Air Pressure Required by Different Sized Tires.

Diameter of Tire, Inches	Maximum Weight on Wheels, Lbs.	Lbs. Per Square Inch
2½	225	50
3	350	60
3½	600	70
4	750	80
4½	1,000	90
5	1,000	90

2. *Drive your car at a moderate speed,* turn corners slowly, and pick your road carefully. From every standpoint, it is best to keep the speed of a car under 25 miles an hour. Twenty

miles an hour is good speed and at this rate one can pick the road carefully and avoid a great many bumps, cans, bottles, etc., which would otherwise not be seen. This speed also gives most miles per gallon of gasoline. Corners and curves should not be turned when a car is making much headway, as excessive strain is thrown on the tires. They are liable to skid and thus increase the tire wear, to say nothing of the danger.

3. *Avoid abrupt starting and stopping.* When the clutch is thrown in suddenly, the rear wheels will spin on the surface of the road before the car gets under way and many miles of service will be lost. The same is true when the brakes are applied suddenly in bringing a car to a stop. The wheels are locked and the momentum of the car drags them along the road for a distance—which is just like holding them to a grindstone. It is a good rule to *control a car as nearly as possible by the use of the throttle and use the brakes sparingly.* Also see that the brakes are properly adjusted. Sometimes more pressure is brought to bear on one wheel than on another and the rear tires do not bear an equal amount of strain. Also have some garageman check up on wheel alignment occasionally.

4. *The care of inner tubes* also deserves a word. Pin punctures in these may be repaired either by the use of a vulcanizer or cement patches. In winter, when the tires do not get so hot in travel, the cement patches give satisfaction. In summer, however, they are inclined to work loose and vulcanizing is more satisfactory. There are some tire "putties" on the market which are also all right. Spare inner tubes should be folded carefully, placed in a box, and talcum powder or powdered soapstone sprinkled over them. This powder should also be used freely between inner tubes and casings of the tires in use. Grease should be kept away from both inner tubes and casings.

CHAPTER XVIII

Keeping Down the Gasoline Bill

WITH gasoline high and prospects of it going higher, every car owner wants to operate his machine with as little gasoline as possible. In order to do this, let us give a little study to the ways in which gasoline is consumed and see if some of these ways are not unnecessary.

When gasoline is burned in your car, it generates energy which the engine makes available in rotary motion. The more times, therefore, you can make a gallon of gasoline rotate the engine crank-shaft, the more miles you will get from it— *if* everything else is all right.

First of all, the carburetor should be adjusted so that it will use a minimum amount of gasoline and give a maximum amount of power. More gasoline than can be burned clean should not be fed the engine and the "leaner" the mixture you can use the better. If a rather lean mixture is used, it may be a little hard to start the motor sometimes, but a choke is usually provided for this, and the engine will run all right when it gets hot. Sometimes if a carburetor is adjusted for easy starting, an abnormal amount of gasoline will be consumed in actual road operation when the engine gets hot.

Then, if the carburetor is adjusted so that the gasoline will give up the largest possible amount of energy, one should see that this is used to best advantage. First, everything should run smoothly—have snug adjustment, yet not too tight, and be well lubricated.

Then, too, the carburetor may mix the gasoline with air economically and yet the engine not deliver the power it should. This indicates a power waste somewhere that may be blamed

on the motor and one should look for leaks in the intake manifold or unions, leaky valves, deposits of carbon in cylinders, clogged muffler, leaky piston rings, scored cylinders, missing cylinders, lack of lubricating oil, poor gaskets, weak valve springs, and dirty interrupter points.

The position of the spark lever also has a great deal to do with gasoline consumption. The spark lever is for adjusting the time at which the charge in the cylinders shall be fired. It takes gas just an instant to become ignited and expand. When an engine is running fast therefore, the gas has to be ignited *ahead of time* in order to exert its full expansive force on the piston head. If it is ignited just as the piston gets on "center," the piston will have almost completed its stroke before the explosion occurs. When an engine is turning rapidly, therefore, the spark should be kept advanced as far as your ear tells you it will run best; and of course, when the engine is turning over slow, the spark should be retarded. The spark should also be retarded when an engine is cranked. No leaks should be tolerated in the gasoline system. Sometimes the pipe connections will work loose because of vibration. In this case they should be immediately tightened. The carburetor also leaks sometimes, and this is often caused by sediment collecting in the float feed needle valve. Jarring the carburetor slightly will often remedy this, as well as starting the motor and speeding it up to suck out the foreign matter. Less often leaks are caused by an oil-soaked cork or a punctured metal float or a poorly seated needle valve.

And above all things, the motorist should seek to save gasoline while the car is in actual operation. Here are a few points on this problem:

1. Arrange your gasoline feed lever so that you may cut off

all the gasoline from the engine if you will. This may be used to advantage when coasting down hills. Cut off the gasoline and let gravitation run your car while it will instead of having the engine use some gasoline and then bring the brakes into play to keep it from running away. This is true in stopping a car, as has already been mentioned.

2. Do not run your car at a fast clip until ready to stop and then apply the brakes suddenly. On the contrary, the engine may be shut off, the clutch disengaged, and the car allowed to coast to a standstill in many instances.

3. Then, too, if you stop your car to have a long conversation with someone, shut off the motor.

4. Do not form the habit of "warming up" the engine of your car before you start out on the road. This is useless. Use the gasoline to get over the road.

5. Under inflated tires also increase gasoline consumption.

CHAPTER XIX

Caring For Your Automobile In Summer

WHEN driving an automobile in summer, one should take care to see that the motor does not overheat. In winter it is sometimes necessary to have a radiator cover in order to keep the engine hot enough to run well, but the problem is just the opposite in hot weather.

Never is it so important to see that the engine has plenty of the right kind of oil as at this season of the year. A good many cars require a different kind of oil in summer—one that has more body than is required in winter—and this is especially necessary in engines that have been used quite a while.

Then the cooling system deserves attention. If there are any leaks in the radiator or piping, have them fixed. Also be sure that the water is free to circulate and that there is enough water in the radiator to allow circulation.

Sometimes the habit of driving with a retarded spark is formed in cold weather, because this will cause the engine to heat readily and therefore run smoother at that season, and the habit is not changed when hot weather does come. Driving an engine at high speed with a retarded spark will cause it to become excessively hot during warm weather and this should be avoided.

Also see that the fan belt is in good condition and that it is tight enough to drive the fan at its maximum speed. Wipe this belt free of oil and grease occasionally. Belts should have enough grease to be soft and pliable, but large amounts of grease will allow them to slip.

Sometimes the flow of water in the cooling system is hindered by improperly cut gaskets or carelessness in placing connecting pieces of hose. In placing these pieces of hose, some-

times the inner lining is folded back, covering the opening of the pipe and thus obstructing the flow of water.

If the engine is loaded with carbon deposits, it will also overheat. The same thing is true if the valves need grinding, or the ignition is out of time, or if a rich mixture is fed, or if the muffler is clogged with soot.

The tires also deserve especial care in summer, as heat affects them in several ways. One thing that the heat does is to cause the air in the tires to expand. Most manufacturers specify that a certain pressure be maintained in their make of tires at all times regardless of weather, but it is usually best to reduce the pressure ten pounds in very hot weather. Friction between tires and hot roadway cause the air to expand in the tires and if they are old, there is quite likely to be a blow-out if they are inflated to capacity when cool.

When a car is left standing, it should be placed in the shade, if possible, not only on account of the paint or enamel, but because heat will damage the tires. If the car cannot be placed in the shade, then cover the exposed tires with something. Spare tires should also be carried in cases so that they will be protected.

Puncture patches also give more trouble in summer. The prepared patches give excellent service in cold weather but sometimes the heat of summer will cause them to work loose. It is therefore safest to vulcanize punctures.

In hot weather water will also evaporate more rapidly from the storage battery, and this should have close attention.

CHAPTER XX

Caring For Your Automobile In Winter

WHEN motor cars were being developed, it was the usual thing to store them during the winter months; now it is customary to use them the year round.

If a car is to be kept in service, the most important point to be considered is the proper care of the cooling system, and a good anti-freezing compound or solution should be provided in order to protect this vital part.

Without doubt, the best substance to use is denatured alcohol. This has no destructive effect on metals or rubber hose and will form no deposits in the pipes of the cooling system. Its chief disadvantage is that it evaporates easily and has a low boiling point. For this reason, there is danger of letting the solution become too weak.

The following table shows the amount of denatured alcohol needed, and the temperatures at which each mixture will freeze:

Alcohol	*Water*	*Freezing Point*
5 per cent	95 per cent	25 degrees above zero
15 per cent	85 per cent	11 degrees above zero
20 per cent	80 per cent	5 degrees above zero
30 per cent	70 per cent	9 degrees below zero
35 per cent	65 per cent	16 degrees below zero

Various mixtures of water, glycerin and alcohol have been tried with good results. While glycerin itself has a decomposing effect on rubber hose, the small amount it will be necessary to use in a mixture of this kind will not be harmful. The reason for adding the glycerin is that it greatly reduces the evaporation of the alcohol and water. The best mixture is one of half alcohol and half glycerin.

The freezing temperature of such a solution in varying proportions is as follows:

Alcohol and Glycerin	*Water*	*Freezing Point*
15 per cent	85 per cent	20 degrees above zero
25 per cent	75 per cent	8 degrees above zero
30 per cent	70 per cent	5 degrees below zero
40 per cent	60 per cent	23 degrees below zero

The proper proportion of the above mixture must, of course, be governed by the locality, but it is better to be safe than sorry. For this reason, make the solution strong enough for any extremes to be expected. The glycerin in such a solution will remain practically the same, while water and alcohol must be added as evaporation takes place.

If the automobile is not used very frequently, the cooling system may be drained each time the car is put away and refilled again when it is necessary to use it. When this plan is adopted, the cooling system may be filled with hot water when the weather is extremely cold and thus aid in starting the engine easily. When no anti-freezing solution is used, however, one is always afraid to leave a car standing idle very long because of its liability to freeze up.

It is very often troublesome to start a motor in winter. This may be overcome by filling the engine cooling system with hot water when no anti-freezing solution is used, and when the cooling system is not drained each time the motor is stopped, the same purpose may be accomplished by priming the motor or pouring hot water on the carburetor and intake manifold.

Most engines have priming cocks fitted in the cylinder heads through which priming fluid may be injected in to the cylinders. If priming cocks are not provided, the spark plugs may be removed for this purpose. High-test gasoline or a mixture of half gasoline and half ether should be used for this

priming. The latter mixture should be kept tightly corked to prevent evaporation.

The object in pouring hot water on the carburetor is to heat the gasoline it contains so that it will vaporize easily, and the result may be hastened by wrapping the carburetor with a woolen rag to arrest the water and keep it in contact with the carburetor for a greater period.

One should also see that the storage battery is kept well charged during cold weather. A charged battery will not freeze, but a discharged one will do so.

CHAPTER XXI

Worth-While Accessories

THERE are a great many articles of equipment and accessories which are not included in the original equipment of the modern automobile, but many of the things that once cost extra money and were considered luxuries are now conceded to be necessities and are included in the equipment as a matter of course.

Every car should have a speedometer, and if anyone has a car not equipped with such an instrument, it will be well to buy and install one. Unless a car does have a speedometer, it is impossible to know how much service you are getting out of tires, and if tires do not give their guaranteed mileage you have nothing on which to base your claims for adjustment.

Shock absorbers are another thing worth putting on a car that has stiff springs. These not only give a car greater comfort, but add to its life by eliminating a large amount of vibration.

Every car should carry one or more spare tires complete, as well as two or three extra inner tubes. The spare tires should be protected by tire coverings and the tubes should be folded, dusted with powdered soapstone or talcum powder and placed in boxes.

If much touring is done, a folding rubber bucket should be carried along with which to fill the radiator whenever it is necessary.

A small steam vulcanizer is almost indispensable in repairing pin punctures in inner tubes and cuts in tire casings. Prepared patches should also be kept on hand at all times, as well as a few blow-out shoes.

Most automobiles are equipped with tire pumps, but many

of them are almost worthless. Be sure you have a good tire pump and take it with you on all trips.

One should also have a good assortment of tools. This line of equipment that usually comes with cars is inadequate. Every car should carry the following tools:

1 center punch.
1 bunch of wire.
3 end wrenches of various sizes.
1 pair cutting pliers.
1 chisel.
1 box of split-pins.
1 box of assorted nuts.
1 pair combination pliers.
1 small and 1 large screw driver.
1 pipe wrench.
1 mechanic's hammer.
1 monkey wrench.
1 rat-tail file.
1 three-cornered file.
1 split-pin extractor.
1 flat file.
1 file handle.
1 oil can.
1 wheel jack.
1 small hand vise.
1 pair of scissors.
1 set of spark plugs.
1 trouble lamp.
1 set of tire tools.

Besides the above equipment, one should keep in his shop or garage the tools necessary to make ordinary repairs. This at least should include a set of socket wrenches, a blow torch,

several heavy wrenches, a hacksaw and several blades, a heavy vise, some carbon scrapers, a hand drill, and valve-grinding tools.

It is well to keep the car prepared for any emergency, and a great deal of trouble and annoyance may sometimes be prevented by carrying along a small can of lubricating oil, a box of cup grease, and any other things that may possibly be needed.

Above all things, keep the car's tools and equipment in order. Have a place for everything and keep everything in its place. This is the only way to get real car service. Have your car so equipped that you will have no fear of not getting back home all right when you start out on a trip.

CHAPTER XXII

Keeping the Car "Like New"

IN ORDER to keep the farm automobile looking well and in good trim, two things are necessary:

1. It should be kept clean and driven carefully.
2. It should be repaired and adjusted promptly.

One thing that makes a car look new, is a nice body finish, and many motorists are at a loss to know why the brightly varnished or enameled surface sometimes quickly loses its gloss. Here are some of the reasons why this happens: (1) Mud is allowed to dry on the body of the car and stay for days at a time. (2) Grease is permitted to collect on its surface. (3) The car is left standing out in the sun and wind and rain for long periods. (4) The car is stored in the barn where the ammonia fumes from the manure are allowed to get in their gloss-destroying work. The remedies for these things do not need discussion.

One should be very careful about the kind of soap used in washing a car. Many of the compounds used contain alkaline materials which are very harmful to paints and varnishes. It is well to buy a soap made especially for use in washing cars and then use this sparingly. Where grease is to be removed from the running gear, use kerosene instead of soap.

When a car is to be washed, the dust should be flushed off by gently pouring water over the car body and wheels or by the use of a hose or pump. If a hose or pump is used, the water should not be thrown on the car body with much force until all grit has been flushed off. If any mud cakes have become dry, wet them and let soak for a while before trying to remove them. After all dirt and dust have been removed, a sponge and soap

may be used lightly, if necessary. A prepared body dressing may be applied after washing.

The top should also be given attention. In cleaning mohair tops, dust may be removed with a moist sponge and grease and oil stains taken off with soap and water. Leather and imitation leather tops may be washed off and treated with some one of the many prepared leather dressings. Before applying any type of dressing, it is advisable to make an application of neatsfoot oil till the leather has been softened—and often this oil treatment will be sufficient.

Now then for our second point—making repairs and adjustments promptly. When your car is new, it will run like a top and you will learn to know how a perfect running car sounds. Then, when something develops in the way of a noise that you are not accustomed to hearing, do not be satisfied until you learn what is the cause and remove it. It may be that a small bolt or nut has been lost from a fender which allows it to rattle; it may be a loose hood or dust pan; it may be the windshield, or a hundred other things. Whatever it is, find the trouble and remedy it.

Then keep all bearings adjusted. Do not tolerate lost motion anywhere. Keep the tires well inflated and all cuts repaired. Do not drive fast or try to pass someone just to say that you "dusted" them. In short, take pride in your car and treat it accordingly. It will pay. All the things treated in this little book tend toward keeping automobiles in good shape and it is almost useless to elaborate on them. Remember though that a car is about as young as it looks and sounds.

CHAPTER XXIII

Car Care in a Nutshell

The New Driver Should Remember—

1. To study carefully the instruction book of his car.
2. That he should practice the use of various levers till he operates them automatically.
3. That fast driving is extremely dangerous, especially for an inexperienced driver, and is uneconomical.
4. That a car should be kept under perfect control at street corners and road intersections.

Confidence in Self and Car Comes Through—

1. Learning everything possible about your automobile.
2. Taking adequate tools for repairing with you at all times.
3. Carrying along extra parts, such as tires, inner tubes, patches, wire, nuts, bolts, oil, pin grease, etc.

To Adjust Carburetor—

1. Start the motor and open the throttle so it will run at a good speed.
2. Screw down the needle valve until the motor threatens to stop.
3. Open up the needle valve again until the motor gains its maximum speed and begins to slow because of excess gasoline.
4. Screw down needle valve again until motor again reaches maximum speed.
5. Leave throttle lever in same position while adjusting.

To Get Good Service From Vacuum Fuel Feed—

1. Strain all gasoline that goes into fuel storage tank.
2. Drain sediment from storage tank and vacuum tank every time car is run 2,500 miles.

3. Keep top of vacuum tank on tight and have all pipe connections in good shape.

4. Keep air vent in storage tank open.

To Grind Valves—

1. Expose valves to be ground by removing cylinder head or screw plugs.

2. Remove valve spring.

3. Lift valve from its seat and smear surface with grinding compound and turn with a rotary motion by use of screw-driver or forked grinding tool.

4. It is well to place a weak spring under the valve being ground so that when pressure is removed the valve will be lifted. The lifting of the valve frequently is necessary in order to allow the grinding compound to redistribute itself.

5. Keep grinding compound from valve stems and do not allow it to get into cylinders.

6. Use coarse compound when beginning to grind and finish off with a fine compound.

When You Dismantle An Engine—

1. See that cog wheels driving magneto and camshaft are marked properly so that they may be reassembled in right relation to each other.

2. Also see that flywheel is marked to correspond with some part of engine so that the crankshaft may be set in proper position before an attempt is made to place the gears.

The Magneto May Be Kept in Good Shape By—

1. Not monkeying with its "insides."

2. Keeping the breaker points and distributor brush clean.

3. Giving the main bearings a drop or so of oil every 500 miles.

4. Keeping it wiped free from accumulating dust and oil.

Vibrators Will Work Well If—

1. Kept properly adjusted.
2. Points are smooth and free from dirt.
3. Fastened securely in box.
4. Protruding end of core is kept clean.
5. There is a good current.

Spark Plugs Should Be—

1. Kept clean.
2. Snug in pockets.
3. With properly adjusted points.
4. Screwed tight to current wires.

The Motor Lubricating System Should Be—

1. Kept filled with oil to the proper level.
2. Free from leaks.
3. Drained free of oil and washed out with kerosene every 2,500 miles.

Automobile Bearings Should Be—

1. Kept well lubricated.
2. Properly adjusted.
3. Free from dirt and grit.
4. Given enough slack in making adjustments to avoid over-heating.

The Life of the Clutch Will Be Lengthened If—

1. It is engaged gently.
2. Kept adjusted.
3. Kept well faced (if cone clutch) or well oiled (if multiple disk clutch).
4. If speed of engine is brought to approximately proper ratio with clutch before engaging.

When Shifting Gears—

1. Never try to make changes with the clutch engaged.

2. In starting a car, first set the speed in low gear and gently engage clutch.

3. In changing from slow to second speed, disengage clutch, slow engine, and after hesitating an instant make change to intermediate. This also applies when changing from second to third.

4. In changing from a high speed to a lower speed, slip the gear shift lever in neutral, speed up the engine, engage the clutch for an instant, after which release the clutch and shift to the lower speed.

5. Never engage the reverse gear when the car is in forward motion, as the gears will invariably be stripped.

The Differential Will Give Longest Service When—

1. A car is habitually started off gently.
2. Kept well lubricated.
3. Washed out with kerosene every 2,500 miles.

To Get Best Service From Electric System—

1. Never try to crank engine with clutch and gears engaged.

2. Never crank the engine continuously for long periods. If it does not start readily, do not exhaust storage battery in cranking but look for the trouble.

3. Never leave car standing at night on street or at church with all lights burning. Dim them.

4. Never leave lights burning all night.

5. Keep batteries well supplied with distilled or rain water.

6. Never add acid to the batteries.

7. Main bearings of motor and generator should receive frequent lubrication.

8. Keep batteries fastened to frame of car securely.

9. Rub battery connections with vaseline occasionaly to counteract action of acid.

10. Replace promptly any lost filler caps.

11. If electrolyte is lost from batteries (spilled) have your service man supply more.

12. Buy a hydrometer syringe and test batteries frequently.

Brake Service Will Be Bettered If—

1. They are applied gently.
2. Linkage kept well adjusted and oiled.
3. The brakes themselves properly adjusted.
4. The engine is allowed to help brake by cutting off gasoline and running against compression in going down hills.
5. Gasoline feed is used to control car as much as possible and brakes used sparingly.
6. Two sets of brakes are used alternately in going down long hills.
7. Brakes are not allowed to drag.
8. Adjust so equal pressure is given each wheel.

Tires Will Give Maximum Service When—

1. Kept inflated at proper pressure.
2. Car is driven at a moderate speed.
3. Abrupt starting and stopping is avoided.
4. Cuts in inner tubes and casings are repaired promptly.
5. Roads are carefully chosen.

You Can Save Gasoline By—

1. Having carburetor adjusted for as lean a mixture as is practicable.
2. Keeping everything well lubricated.
3. Avoiding dragging brakes.

4. Using gasoline feed to control car as much as possible instead of brakes.

5. Keeping spark-lever advanced.

6. Not allowing leaks in gasoline system.

7. Keeping all cylinders firing.

8. Retaining good compression.

9. Having ignition and exhaust in perfect time.

10. Keeping tires inflated.

11. Not carrying on long conversations with someone by the way while the motor keeps running.

12. Avoiding speeding.

13. Forgetting to "warm up" engine before you start on road.

When Driving a Car in Summer—

1. Keep the radiator full of water.
2. See that water circulation is not hindered in any way.
3. Keep plenty of oil in motor lubricating system.
4. Never leave car standing in the sun.
5. Put distilled water in batteries more frequently.
6. Keep spare tires covered.
7. If car must be left in sun, cover exposed tires with cloths.

When Driving a Car in Winter—

1. Fill cooling system with a good anti-freeze solution or drain out water when engine is stopped.
2. As a usual thing use a thinner grade of lubricating oil than in summer.
3. See that the storage battery is kept well charged at all times.
4. Keep tires well inflated, as they are especially liable to cuts when driven on ice or frozen ground.
5. Use chains when driving over muddy or frozen roads.

6. Keep your car well housed.

7. For quick starting on cold days pour hot water on the carburetor to make the gasoline vaporize easily.

What to Do Every Day—

1. See if radiator is full of water.
2. Test tires to see if properly inflated.
3. Inspect spare tires and tubes.

What to Do Every Week—

1. Put graphite grease in cups on steering yoke bolts.
2. Oil brake linkage.
3. Put distilled water in batteries.
4. Wash car.
5. Tighten all loose nuts, bolts and screws.

What to Do Every Two Weeks—

1. Put grease in front hubs.
2. Oil starter bearings.
3. Inspect and oil tire pump.
4. Put grease in spring grease cups.

What to Do Every Month—

1. Fill all steering device oil cups.
2. Change oil in engine oiling system.
3. Change oil in transmission.
4. Grease universal joints.
5. Oil pedal support shaft.
6. Oil brake levers and hangers.
7. Fill rear-wheel bearings and grease-cups.
8. Put grease in differential.

CHAPTER XXIV

What To Look For In Case of Trouble

An Engine Won't Run When—

1. Out of gasoline.
2. The switch is off.
3. There is a short-circuit or loose wire in the ignition wiring.
4. The valves or ignition are out of time.
5. There is very poor compression.
6. The gasoline feed pipe is stopped up.
7. There is sediment in carburetor needle valve.
8. The mixture is too lean.
9. The mixture is too rich.
10. It is too cold.
11. Out of lubricating oil.
12. Vibrator points are stuck.
13. Bearings are swelled from overheating.

When An Engine Misses Fire Look For—

1. Fouled spark plug.
2. Loose wire connections.
3. Broken wires.
4. Dirty distributor or commutator.
5. Improper carburetor adjustment.
6. Poor compression.
7. Leaky or ill timed valves.
8. Loose cylinder head, spark plugs, intake manifold.
9. Too much lubricating oil.
10. Water in gasoline.
11. Partially clogged fuel pipe or needle valve.
12. Improperly adjusted or rough vibrator points.

An Engine May Run Yet Have Little Power Because of—

1. Worn piston rings or cylinders.
2. Leaky valves.
3. Valves or ignition slightly out of time.
4. Leaky cylinder head, spark plugs, priming cocks, intake manifold.
5. Too rich mixture.
6. Too lean mixture.
7. Lack of lubricating oil.
8. Bearings adjusted too tight.

When An Engine Overheats Look For—

1. Lack of lubricating oil.
2. Not enough water in cooling system.
3. Leaky radiator or pipe connections.
4. Clogged pipes.
5. Scale formed on interior walls of cooling system.
6. Engine operated with spark retarded too much.
7. Dragging brakes.
8. Bearings too tight.
9. Broken fan belt.
10. Radiator daubed with mud or covered with number plate.

An Engine Knocks and Pounds Because of—

1. Loose bearings.
2. Loose in car frame.
3. Valve tappets improperly adjusted.
4. Spark advanced too much on a hard pull.
5. Accumulation of carbon.
6. Pre-ignition.

Body Noises May Be Due to—

1. Loose fenders.
2. Uncoiled springs and shackle bolts.

3. Unfastened hood.
4. Loose radiator.
5. Fan bent so it strikes radiator or some part of engine.
6. Loose dust pan.
7. Loose brake bands and linkage.
8. Poorly packed tool box.
9. Tire chains adjusted so they hit fenders.
10. Loose number plate.
11. Loose steering knuckles and linkage.
12. Shaky doors.
13. Loose top supports.
14. Loose windshield.

INDEX